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Xanthostemon aurantiacus (Brongn. et Gris) Schltr. - Chutes de la Madeleine, New Caledonia

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New Caledonia. New Caledonia is a hot spot with a high degree of endemism and a rich biodiversity (for instance about 3.300 species of plants have been recorded thus far, including the richest concentration of conifers in the world: 44 species, among them 13 species of the genus *Araucaria* and the only known parasitic conifer, i.e. *Parasitaxus ustus*). The presence of several phylogenetic relicts and the circumstance that it was originally a fragment of Gondwana pointed towards a "continental island", but more recently, geological evidence indicating Palaeocene and Eocene submersions and biogeographic and molecular phylogenetic studies support the view that New Caledonia is a biota not older than the Oligocene (Grandcolas et al., 2008). The island is therefore a "Darwinian island", although an old and large one. The main island (Grande Terre) hosts a diverse array of habitats, including moist lowland forest, cloud forest, dry forest, mangroves, savannah and the "maquis minier": this strange habitat is characterized by the presence of ultramafic rocks, toxic and poor of nutrients for the majority of plants. Nonetheless several endemic species of plants thrive there, forming a landscape somewhat similar to the South African Fynbos, although in the tropics. The images show some fine examples of the flora typical of maquis minier: a small *Lomandra insularis* (Asparagaceae) (right, center) growing in the middle of lichens (*Cladia retipora* and *Cladonia pycnoclada*) (also right, top), and the flower of *Cunonia macrophylla* (Cunionaceae) (right, bottom).

Alberto Ballerio, Viale Venezia 45, 25123 Brescia, Italy;
e-mail: alberto.ballerio.bs@aballerio.it

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Aphaenogaster muelleriana Wolf, 1915 (Hymenoptera Formicidae) in Salento (South East Italy)

Antonio Scupola

Museo Storia Naturale di Verona, Lungadige Porta Vittoria 9, 37129 Verona, Italy; e-mail: scupolant@outlook.it

ABSTRACT Workers of the ant *Aphaenogaster muelleriana* Wolf, 1915 (Hymenoptera Formicidae) have been found in Salento (Apulia, South East Italy) for the first time. Also, this record represents the first citation for the Italian peninsular territory. New Italian localities for *A. splendida* species-group are given here.

KEY WORDS Ants; *Aphaenogaster muelleriana*; *A. ovaticeps*; *A. splendida*; first citation, Formicidae, Italy.

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INTRODUCTION

In July 2016 during my myrmecological researches in Salento (South Apulia) I had the chance to collect some specimens of the nocturnal *Aphaenogaster* (*Attomyrma*) *muelleriana* Wolf, 1915 (Hymenoptera Formicidae Myrmicinae Stenammini).

This Balkan ant species was up to now virtually unknown on the Italian mainland, having only two historical records reporting localities close to the Slovenian borders. The Salentinian specimens represent the first citation for Apulia and for the entire Italian peninsular territory.

MATERIAL AND METHODS

The specimens are stored in the following collections: ASPC: Antonio Scupola personal collection (Verona, Italy); CGPC: Christophe Galgowski personal collection (Saint-Aubin-de Médoc, France); ESPC: Enrico Schifani personal collection (Palermo, Italy); BMNH: The Natural History Museum of London U.K.; MSNM: Museo di Storia Naturale di Milano, Italy; MSNV: Museo di Storia Naturale di Verona, Italy; VGPC: Vincenzo Gentile personal collection (Napoli, Italy).

Measurements were taken by means of an ocular graticule mounted on Leica MB3 stereomicroscope at 60X magnification. The measures are express in mm; The following acronyms have been used: CL (cephalic length, measured from the anterior edge of the clypeus to the posterior border of the head); CW (maximum width of the head, measured immediately after the eyes); SC (scapus length, measured without the basal condyle); CI (cephalic index: CW/CL); CS (cephalic size: CW+CL/2).

RESULTS

Aphaenogaster* (*Attomyrma*) *muelleriana Wolf, 1915

EXAMINED MATERIAL. New data. Italy, Salento (Lecce Province, Apulia),Torre Vado, loc. Postu Vecchiu, 9–16.VII.2016, (at the base of a little wall near a house with garden), leg. A. Scupola; 15 workers.

DISTRIBUTION. Emery (1898) first mentioned the *Aphaenogaster muelleriana*, nevertheless without giving a formal description of it. Subsequently Emery (1914) cited as *A. ovaticeps* new subspecies, a series of workers from Cephalonia, but also in this case without providing a formal description. He writes: "*wird dr. K. Wolf, der die arbeiterin derselben bei Triest fand, unter dem namen subsp.* Mülleriana *beschreiben*". ["...Dr. K. Wolf describes the worker found in the surroundings of Trieste under the name subspecies *mülleriana*."].

Wolf (1915), finally, describes *A. ovaticeps* ssp. *muelleriana*, on a single specimen (Müller legit) from Castle of Miramare near Trieste.

After the original description, new specimens are signaled from Trieste (Finzi, 1922; Müller, 1923; Finzi, 1927) and Gorizia (Baroni Urbani, 1962). *A. muelleriana* is reported also from Slovenia (Bračko, 2007), Croatia (Zimmermann, 1935; Bračko, 2006), Bosnia and Herzegovina (Zimmerman, 1935), Serbia (Petrov & Collingwood, 1992), Montenegro (Zimmermann, 1935; Karaman, 1998), Albania (or Greece ?) (Pindo) (Emery, 1898 sub *A. ovaticeps*; Wolf, 1915; Emery, 1916, Finzi, 1927), Greece (Prevesa) (Emery, 1898 sub *A. ovaticeps*; Wolf, 1915); Corfu island (Finzi, 1927), Cephalonia island (Emery, 1914). The presence in Macedonia (Borowiec, 2014) is dubious (not confirmed by Karaman, 2009 and Bračko et al., 2014).

REMARKS. The systematic position of *A. muelleriana* is actually still unclear. This taxon for a long time has been considered only a subspecies of *A. ovaticeps* Emery, 1898, (endemic species from Liguria (North West Italy), as the differences found in the workers (head more slender and posterior much transverse, head surface more polish, propodeal spiny less developed) and found in the draws of the males (Wolf, 1915, based on the draws of Emery, 1898), were weak but constant.

Müller (1923) studied the particular populations of *A. ovaticeps* ssp. *muelleriana* from Split (loc. Castella) (Central Balkan). He noticed that at first sight, the specimens are convergent with *A. ovaticeps* s. str. (head opacity and form of the propodeal spiny), but in the same time, he found some differences in males and in particular in the workers (he compared the draws of Emery, 1908) (postpetiole lower in profile as in *A. muelleriana*, and head more slender respect to *A. ovaticeps* s. str.). Müller then considered these populations as a possible separate new subspecies (not described), besides affirms that the Albanian (Grecian ?) populations are probably co-specific with this new subspecies.

Finzi (1927) observed that the population of *A. ovaticeps* ssp. *muelleriana* from Trieste, differs from *A. ovaticeps* s. str. only for the brightness of the vertexal, since the morphology of the head and propodeal spiny are subject to intranidal variation. He notices, in particular, that a specimen of *A. ovaticeps* s. str. from Genoa, (collected by Mantero in the year 1911), has a typical short propodeal spiny, while a specimen of *A. muelleriana* from Trieste has a longer propodeal spiny compared to those of *ovaticeps* s. str. Finzi (1927) had not enough materials to solve this problem and he never took in consideration males reported from Pindo and Preveza (Greece).

Emery (1908) writes that the male of *A. ovaticeps* (sic!) (= *muelleriana* ?) from Pindo (Albania or Greece ?) has the wings "*gelblich*" (yellowish) and propodeal spiny less leaning, while the male from Genoa (f. typ.) has the wings "*farblos*" (colourless) and the propodeum more leaning. Finzi (1927), in every case, accepts "*sic et simpliciter*" the vision of Müller, and considers the three followings entities:

Aphaenogaster ovaticeps s. str. from Genoa (North West Italy: Liguria)

Aphaenogaster ovaticeps ssp. *muelleriana* from Trieste (North East Italy: East Friuli and North West Balcania)

Aphaenogaster ovaticeps n. ssp. of Müller, from southern Balkans (Split, Albania, North West Greece and Ionian islands).

Agosti & Collingwood (1987) raised *A. muelleriana* to *bona specie* without providing any further information.

Recently, Borowiec (2014) in contrast with the current opinion, considers the possible synonymy between *A. ovaticeps* s. str. and *A. muelleriana* s.l. (inclusive of the new subspecies of Müller). He writes "... *Materials from Corfu suggested that both taxa represent only forms of one species and nests with intermediate specimens were observed*".

Here, I retain useful to provide measurements from the different populations:

Aphaenogaster muelleriana 5 specimens from Salento, Torre Vado (ASCP)

CL	1.280	1.260	1.230	1.230	1.344
CW	1.02	0.944	0.944	0.928	1.024
SC	1.82	1.600	1.600	1.600	1.800
CI	0.797	0.749	0.767	0.754	0.762
CS	1.15	1.102	1.087	1.079	1.184

Aphaenogaster muelleriana 4 specimens from Greece: Aetolia, loc. Akamania (ASCP)

CL	1.232	1.216	1.248	1.072
CW	0.880	0.912	0.960	0.784
SC	1.600	1.600	1.600	1.440
CI	0.714	0.750	0.769	0.731
CS	1.056	1.064	1.104	0.928

Aphaenogaster ovaticeps 1 specimen from Wolf, 1915

CL	1.200
CW	0.905
CI	0.755

Aphaenogaster muellariana holotypus from Wolf, 1915

CL	1.250
CW	0.958
CI	0.766

Wolf's measures perfectly match with my data. In particular *A. muelleriana* fall perfectly into the ranges (min–max) of CI (0.75–0.80); CL (1.10–1.34) and CW (0.79–1.02). Same case for *A. ovaticeps*. This suggests that Borowiec could be right in considering all taxa as members of a single species. On the other hand I observed that the genus *Aphaenogaster* has the tendency to form allopatric species and endemisms, as underlined in the recent revision of the related *A. cecconii* species-group (Borowiec & Salata, 2014).

In this optics it is therefore possible that the vision of Müller could be correct and new synonymies premature. I think that only studies based on the males from all populations of the entire areal can clarify the situation.

Here I consider *Aphaenogaster* (*Attomyrma*) *muelleriana* a *bona species*, within the *A. splendida* species-group (sensu Böer, 2013).

A. muelleriana in Salento have a transadriatic origin as many other Apulian insects (for example the tenebrionid beetle *Dendarus caelatus* Brullé, 1832, common in West Greece but in Italy present only in Salento). These species are usually Balkan distributed with the separated presence in Italy in the North East (Friuli) and/or in the South East (Apulia) (Gridelli, 1958).

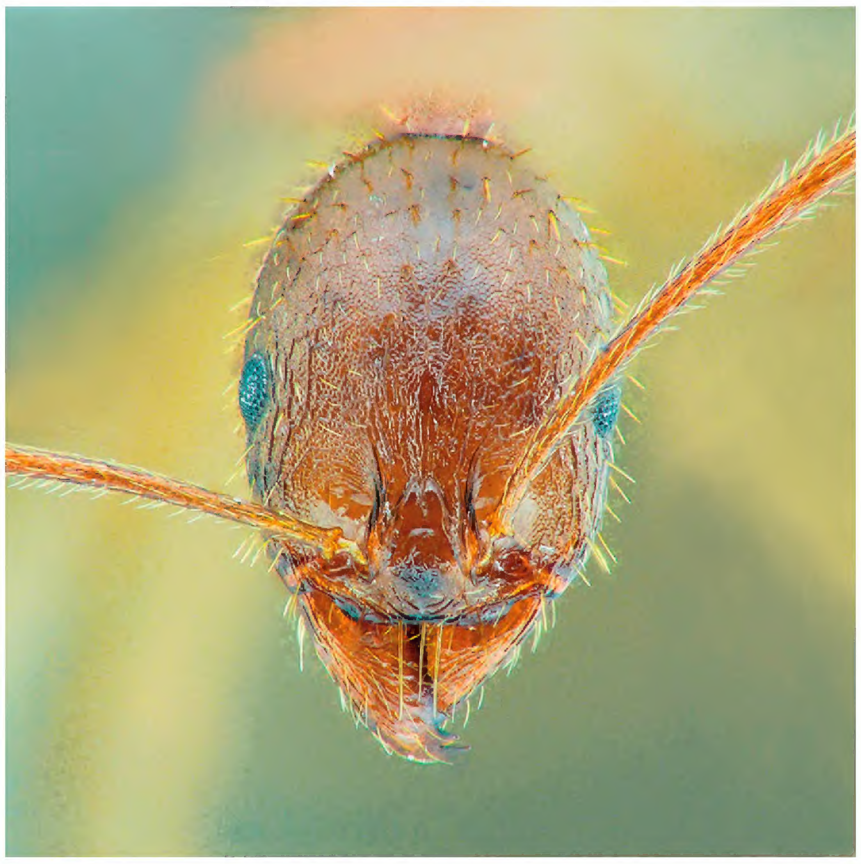

Figure 1. Head of worker of *Aphaenogaster muelleriana* from Torre Vado (Lecce, Italy).

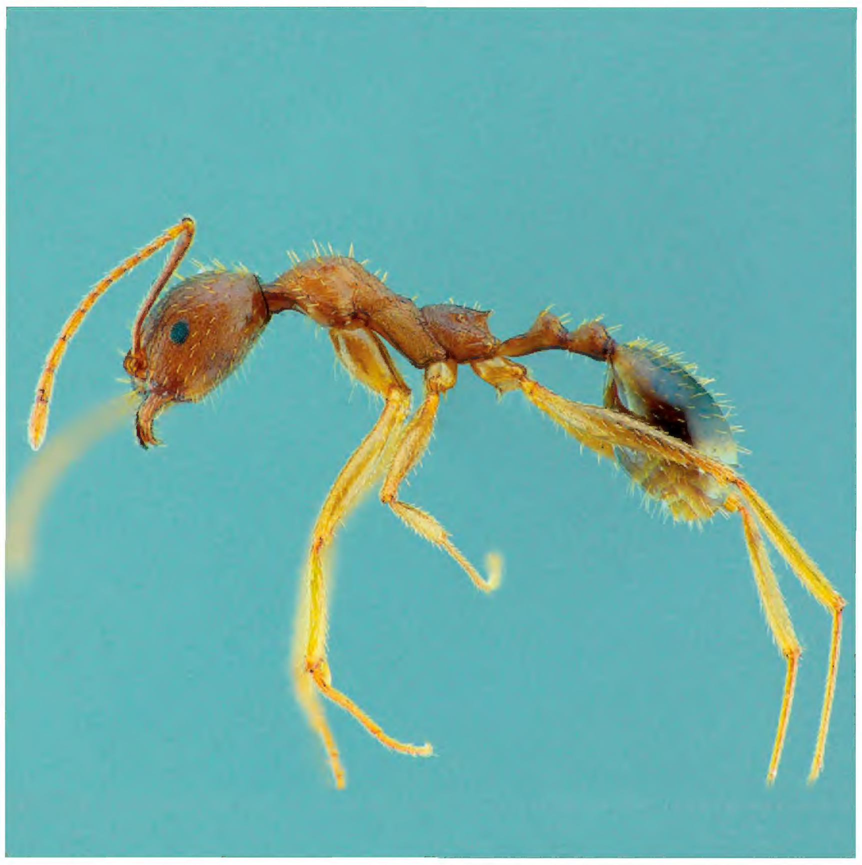

Figure 2. Body of the worker of *Aphaenogaster muelleriana* from Torre Vado (Lecce, Italy).

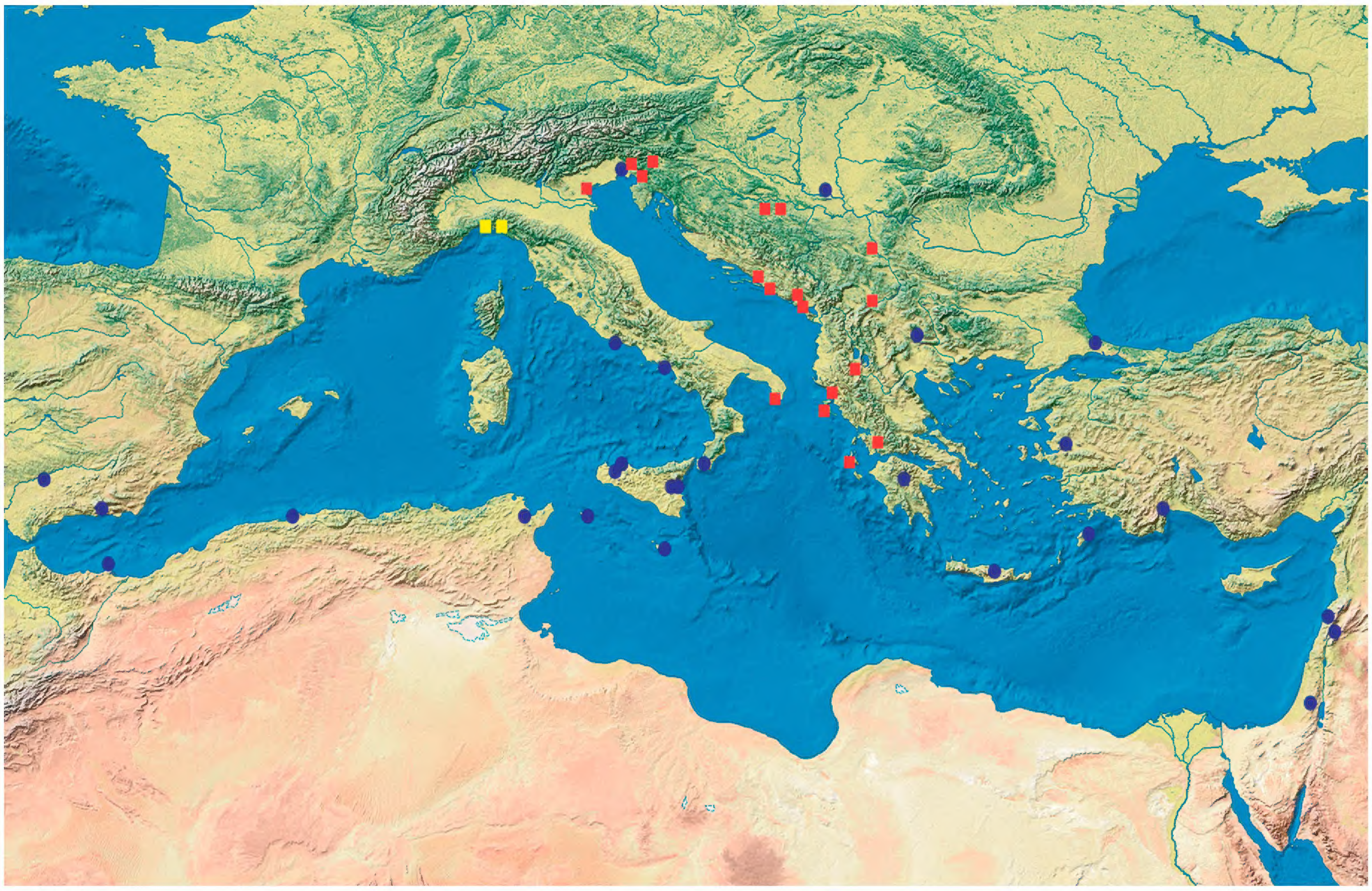

Figure 3. Distribution of the species *Aphaenogaster ovaticeps* (yellow squares), *A. muelleriana* (red squares) and *A. splendida* (blue circles).

NEW DATA ON THE *A. SPLENDIDA* SPECIES-GROUP IN ITALY

Aphaenogaster splendida (Roger, 1859)

EXAMINED MATERIAL. New data. Campania. Praiano di Positano, 9.VII.1966, leg. Poldi, 1 worker (MSNM). Calabria. Reggio Calabria, centro città, 3/VI/04, leg. E. Sgrò, 1 worker (coll. Sgrò); Locri (camping), 1 gyne (dealate) (MSNM). Sicily. Altofonte (Palermo), IX.1963, leg. Genduso, 1 male (MSNM); Tre Mestieri Etneo (Catania), 21.VIII.1960, 1 gyne (MSNM); Catania, 7.VI.2005, leg. Strano, 2 workers, 1 gyne and 1 male (MSNM); Catania, 6.VII.2006, leg. Strano, 2 workers 1 male (ex coll. Sgrò) (ASCP); Catania, 29.V.1993, leg. Poldi, 1 worker (MSNM); Torretta Torra (Bosco della Ficuzza, Palermo) 940 m, X. 2005, leg. Gatto, 1 worker and 2 males (MSNM); Pedara Loc. Tarderia, Catania, 14.VI.1950, leg. Castellari, 1 worker (MSNM); Palermo, 14.IX.2016, leg. Schifani, 1 worker (ESPC).

DISTRIBUTION. Campania; Sicilia, Friuli, Lazio (Baroni Urbani, 1971); Pantelleria (Mei, 1995); Campania, Calabria (present paper).

REMARKS. The workers from Calabria differ from Catania specimens having propodeal spines slightly developed and differently oriented, different sculpture of the mesosoma and less hairy gaster. These differences are not sufficient to hypothesize a different form (Sgrò pers. comm.). On the other side, males of Greece (Aetolia) have a different propodeum profile, suggesting the existence of a different form respect to western Mediterranean populations.

Aphaenogaster ovaticeps Emery, 1898

EXAMINED MATERIAL. New data. Liguria. Chiavari, Genova, 10.VII. 2015, leg. S. Viale, 1 worker, 1 gyne and 1 male (VGPC).

DISTRIBUTION. Genoa (Baroni Urbani, 1971).

REMARKS. Species apparently endemic to Liguria (North West Italy). Collected first by Mantero (1898) but misidentified with *A. subterranoides*

Forel (see Emery, 1916) and subsequently described as new species by Emery (1898).

Aphaenogaster muellariana Wolf, 1915

EXAMINED MATERIAL. New data. Apulia. present paper. Veneto: Mestre-Venezia, 23.IX.1936, leg. Maura, 3 workers (MSNM); Venezia città, 5.VII.1991, 3 workers (MSNM); idem, 3.VIII.1953, 1 gyne (MSNM); 19.VII.1933, leg. Giordani Soika, 1 worker (MSNM); Venezia città, San Polo Portico, 7.VI.1973, leg. Poldi, 1 worker (MSNM).

DISTRIBUTION. Eastern Friuli (Baroni Urbani, 1971), Veneto, Apulia (present paper).

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Does *Leptailurus serval* (Schreber, 1776) (Mammalia Felidae) occur in Western Egypt?

Spartaco Gippoliti[1*] & Aldo Oriani[2]

[1]Parco Zoo Gallorose, Cecina, Italy; e-mail: spartacolobus@hotmail.com
[2]Viale Abruzzi 73A, 20131 Milano, Italy
[*]Corresponding author

ABSTRACT The serval cat, *Leptailurus serval* Schreber, 1776 (Mammalia Felidae), has never been cited from Egypt and Libya in recent time. Here we report the presence of a mounted skin (with skull inside) in a local shop inside the Shiwa Oasis (NW Egypt). The scarcely-spotted pattern exhibited by this skin adds interest to this record. We suggest to secure the specimen to a Natural History Museum and begin an ad hoc investigation in the region.

KEY WORDS Shiwa Oasis; Serval; Sahara.

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INTRODUCTION

The Serval, *Leptailurus serval* (Schreber, 1776) (Mammalia Felidae), is relatively abundant and widespread in Africa with several subspecies and is listed as Least Concern by the IUCN Red List (Thiel, 2015).

There is only one known population of Serval from north of the Sahara, in the Maghreb (Hunter & Bowland, 2013) and it is classified regionally as Critically Endangered. The species has never been historically reported from Libya and Egypt (Hufnagel, 1972; Osborn & Helmy, 1980; Aulagnier et al., 2010). However, as far as Libya is concerned, Holocene remains of the species have been found in Western Libya (Peters & Pöllath, 2004). We noted, incidentally, that a recent map (Hunter & Bowland, 2013) overlooked the distribution of the species along Eritrea - where the species is definitely known from multiple records (Yalden et al., 1980) and probably the Red Sea hills of Sudan.

During a trip to the Shiwa Oasis (NW Egypt), precisely on 6 May 2012, one of us (A.O.) observed in a local shop at the feet of Shali Fortress a very badly mounted skin of a medium sized cat. Two photos were taken of the specimens (Fig. 1), that was immediately identified as a *L. serval*, although it showed a particularly scarce marking pattern.

Siwa Oasis lies approximately 300 km south of the Mediterranean Sea coast, near the border with Libya. It extended in a west-east direction between 29°06’-29°21’N and 25°16’- 26°08’. Surface area is about 1100 km^2 (Goodman et al., 1986).

We consider now useful a publication and description of this specimen as a mean to attract attention to the issue and collect more data (eventually securing the specimen for a museum collection). In first instance, we find the fact that the whole skin is mounted (with skull inside) as an indirect evidence of the local (or very close origin) of the animal, even if we can consider some commerce of sub-Saharan serval skins a likely possibility.

Two distinct coat patterns are known for the serval, and were formerly considered two distinct spe-

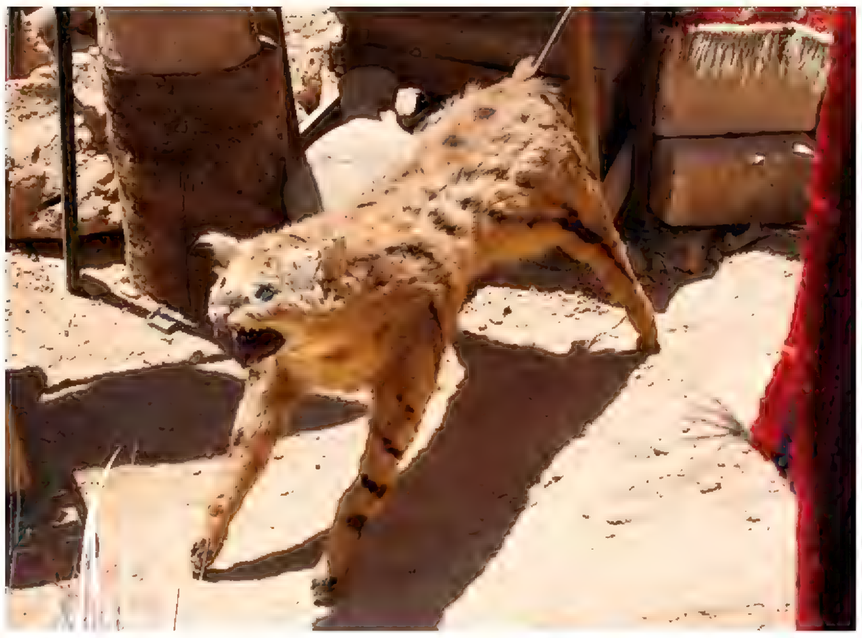

Figure 1. Serval mounted skin found in a shop near the Shali Fortress, Siwa Oasis, 6 May 2012 (photo by Aldo Oriani).

cies (Pocock, 1907); the typical serval pattern with relatively big marking, and the servaline one with minute marking. The present atypical skin is practically spotless, except a number of big black patches found dorsally. From the hind legs two black lines reach the flanks. Underparts are yellowish rather than white.

Furthermore, it is noteworthy the woolly appearance of the coat except for the dorsal area. It seems as the serval was killed during a molt phase. The skin presents a much deeper pelage tone from the 'typical' sandy-buff. This is somewhat surprisingly considering this pattern is found, as a rule, in more humid regions (Rosevear, 1974).

Can such a medium-sized species have escaped researchers until now? Rosevear (1974) reports for West Africa that "*is a not uncommon animal.... Yet as it is only exceptionally on the move during the day, and then mostly skulking in undergrowth, it is rarely seen save in car headlights or by night hunters with powerful lamps*" . It is reasonable that only through ad hoc research we could discover more details on distribution and conservation status of the Sahara serval.

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Biodiversity Journal, 2017, 8 (1): 11–14

Sightings of Red Squirrels *Sciurus vulgaris* Linnaeus 1758 (Mammalia Rodentia) in the Monumento Naturale "Pineta di Fregene" and in the Castel di Guido Oasis (Latium, Italy)

Riccardo Di Giuseppe[1*] & Mauro Grano[2]

[1]Via dei Tre Denari 212, 00057 Maccarese, Italy; e-mail: info@programmanatura.it
[2]Via Valcenischia 24, 00141Roma, Italy; e-mail: elaphe58@yahoo.it
[*]Corresponding author

ABSTRACT This note gives news of the sighting of the Red Squirrel *Sciurus vulgaris* Linnaeus, 1758 (Mammalia Rodentia) in the monumental pine forest of Fregene, nowadays recognized as Federico Fellini Park and of other specimens inside the Oasis Lipu of Castel di Guido. The first sighting is the confirmation of the presence of the species in coastal pinewoods of Latium. The second one constitutes the first report for this area.

KEY WORDS Castel di Guido; Fregene; Monumental Pinewood; urban ecology; *Sciurus vulgaris*.

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INTRODUCTION

The Red Squirrel *Sciurus vulgaris* Linnaeus, 1758 belongs to the Mammals class, Rodents order and Sciuridae family. It is the only native arboreal squirrel in Europe and in most of the Palearctic area. Its area covers, in west-east direction, from England to Japan while in north-south direction, from the Arctic Circle to the Mediterranean, including the Caucasus (Gurnell, 1987). In Italy it is widespread in the Alps and the Apennines, reaching the hillside. In plain it is almost absent because of the excessive fragmentation of its habitat; it is not present in the islands. It is a species related to forest formations, which can be made of conifer, mixed woods or simple hardwoods. It is spread from sea level up to the limit of the forest vegetation (Wauters & Marinoli, 2008).

The species is primarily found in Latium in natural areas near the Apennines, as well as in some urban parks in Rome like Villa Ada and Villa Borghese. It seems to be absent in coastal pinewoods (Capizzi, 2009). The Pineta Monumentale of Fregene, managed as an urban park, is made up of Italian stone pine *Pinus pinea* L. These pines, dated among the oldest of the Tyrrhenian Coastal and probably of the entire Mediterranean basin (Di Filippo et al., 2015), offer a special landscape and natural value, providing an ideal habitat for the red squirrel. The whole area of Castel di Guido, including the homonymous Lipu Oasis, is part of a typical environment and landscape of the Campagna Romana.

MATERIAL AND METHODS

Study area

The Fregene's pinewood, inserted in the "Natural Reserve of the Roman Coast", is one of the best known examples of the Italian coastal pine forest.

It is an area of high cultural-historic value and naturalistic-ecological value. It is a relic of Tyrrhenian landscape before the land reclamation, which started from the end of the 19th century in the Roman coast. Nowadays the area is used by a large number of people for sport and leisure activities. The pine forest is characterized by the presence of century-old specimens of *Pinus pinea* (about 220 years), until now dated among the oldest of the whole of the Mediterranean basin (Di Filippo et al., 2015). In the pine forest, there are areas with a higher density of vegetation. This is especially shown where are typical elements of the Mediterranean maquis such as *Quercus ilex* L., *Arbutus unedo* L., *Erica arborea* L., *Pistacia lentiscus* L., *Myrtus communis* L., *Rhamnus alaternus* L., *Phillyrea angustifolia* L., *P. latifolia* L., *Laurus nobilis* L. and *Ruscus aculeatus* L. This type of plant formation is the primary maquis - known as the original vegetation not altered by man, responding to the climate and flora of the place.

From the point of view of the fauna, the Fregene's pinewood is an area of great interest for its presence of bird species which are typical of old woodlands, such as the red woodpecker *Dendrocopos major* (Linnaeus, 1758) and the green woodpecker *Picus viridis* Linnaeus, 1758. Among mammals we remember the fox *Vulpes vulpes* Linnaeus, 1758 and the hedgehog *Erinaceus europaeus* Linnaeus, 1758.

The territory of Castel di Guido, an agricultural center since the end of the tenth century, has typical characteristics of the Campagna Romana; while the flat areas are cultivated, the steepest parts, which do not allow an easy tillage, are characterized by a typical natural plant formation of Mediterranean climate areas. The area is characterized, in fact, for the presence of evergreen oak such as *Quercus ilex* and *Q. suber* L. which are accompanied by undergrowth made of *Phillyrea angustifolia*, *P. latifolia*, *Rhamnus alaternus*, *Erica arborea*, *Arbutus unedo* and *Pistacia lentiscus*. In this area there are also several examples of typical oaks of the mixed deciduous wood, such as *Quercus pubescens* Willd., *Q. cerris* L. and *Q. crenata* Lam. (Di Giuseppe, 2012).

Inside the reserve 160 bird species have been counted (Cecere, 2006). Among these it is important to underline the presence of booted eagle *Hieraaetus pennatus* (J.F. Gmelin, 1788), of the nightjar *Caprimulgus europaeus* Linnaeus, 1758, of a large colony of bee-eaters *Merops apiaster* Linnaeus, 1758, and some nocturnal raptors as *Tyto alba* Scopoli, 1769, *Otus scops* Linnaeus, 1758, *Bubo bubo* (Linnaeus, 1758), *Athene noctua* Scopoli, 1769, *Asio otus* (Linnaeus, 1758) and *Strix aluco* Linnaeus, 1758.

There are many mammals, as the fox *Vulpes vulpes*, the crested porcupine *Hystrix cristata* (Linnaeus, 1758), the European hare *Lepus europaeus* Pallas, 1778 and recently, even the wolf *Canis lupus* Linnaeus, 1758.

Considering the presence of an important herpetofauna, in 2016 Castel di Guido has been designated AREN (Area di Rilevanza Erpetologica Nazionale, i.e. Relevant National Herpetological Area) by Societas Herpetologica Italica.

Methods

The observation in the Pineta Monumentale of Fregene, lingered for several days and in different times of the day. These observations have been made with the aid of binoculars Minox HG 10X43.

RESULTS AND CONCLUSIONS

This note describes the sighting, in January 2016, of an individual of Red Squirrel *Sciurus vulgaris* in Pineta Monumentale of Fregene (Fiumicino). The specimen was observed for several days by one of the authors, in the early hours of the day, as is typical of the species (Lurz et al., 2005), both on land and in the act of climbing on trees. It was also noted as it entered into a cavity at the top of *Pinus pinea*. The specimen, of which was not possible to determine the sex, had a deep brown color. Nor was possible to understand whether the observations made on different days were referring to the same specimen or to different individuals. This sighting represents a new evidence about the presence of the species in the Pineta Monumentale of Fregene which with its maturity level reached, provides a suitable habitat for this species. The feeding supply is probably based on fruits of *Pinus pinea*, but also on other seeds, fruits and sprouts (Wauters & Dhondt, 1987).

The presence of the squirrel in the pine forest of Fregene is relevant because in recent studies conducted in the province of Rome, it was shown that

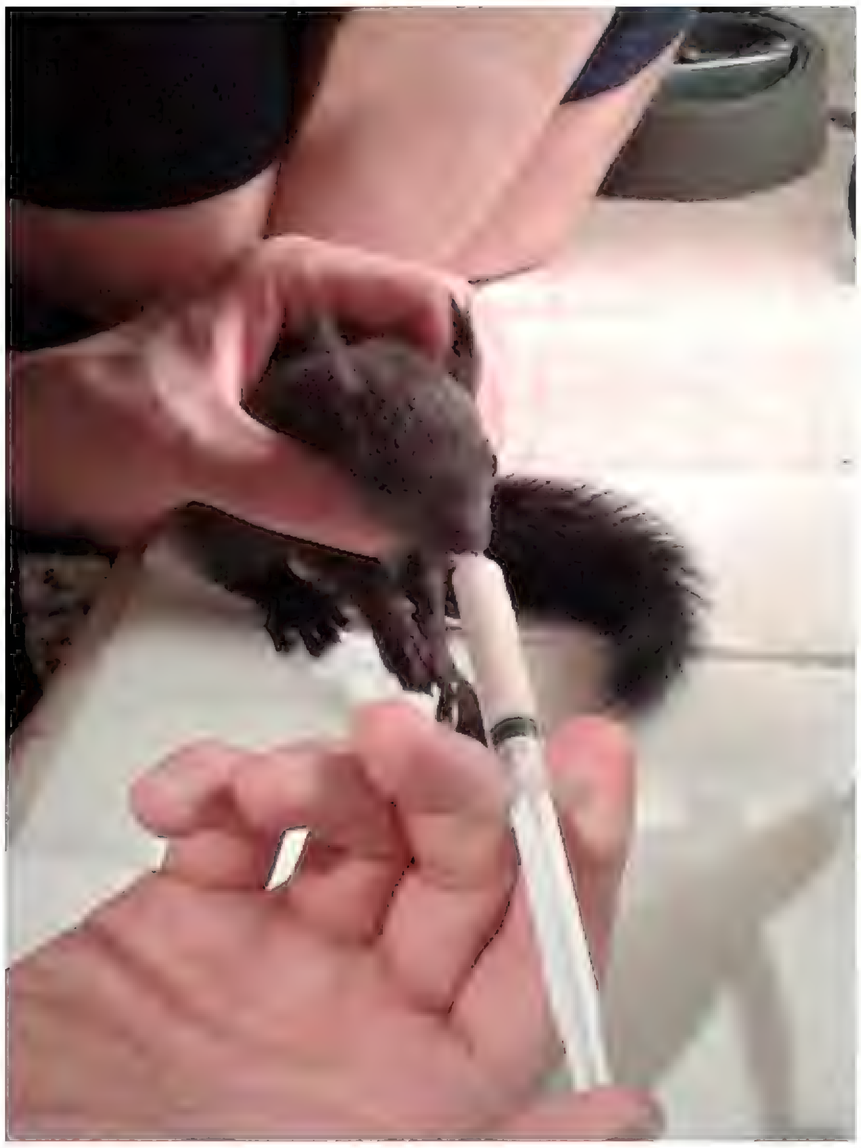

Figure 1. The young Red Squirrel is fed at the Wildlife Rescue Center of Lipu in Rome.

it had turned away from coastal pinewoods (Capizzi, 2009). It is absent, in fact, also in the nearby coastal pinewoods of Castel Fusano and Castel Porziano (A. Cattaneo, pers. com.). On March 2016 at the Oasis Lipu of Castel di Guido, in the village of Castel di Guido (Rome), it was found by some cyclists a young squirrel which was taken at the Wildlife Rescue Centre of Lipu in Rome (Fig. 1). It was a young female still unweaned, released in June in the oasis through an acclimatization cage. A few weeks later in the same site was spotted an adult specimen.

The Maccarese area - Fregene and the Castel di Guido area are separated by anthropic barriers, such as the A12 Civitavecchia - Rome and the railway Rome - Civitavecchia, which create significant ecological fragmentation (Battisti, 2004). However, these two areas are connected to each other through the old Via di Maccarese, which could be a natural ecological corridor for the spread of this species. In conclusion with this note can be confirmed the presence of *Sciurus vulgaris* in the territory of Fregene and in that one of Castel di Guido, places included in the Roman Coast State Nature Reserve. Regarding the area of Fregene, it would be appropriate and desirable to promote in the future specific research and studies to determine whether it is a growing population or some isolated specimens. As concerns the Castel di Guido areas it can be affirmed that the existing population is consolidated and reproductive.

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New record of an irregular sea urchin, *Brissus latecarinatus* (Leske, 1778) (Echinoidea Brissidae) from the Andaman Islands

Naveen Kumar Nigam & Chelladurai Raghunathan

Zoological Survey of India, Andaman and Nicobar Regional Centre Horticulture Road, Haddo, Port Blair-744102, Andaman and Nicobar Islands, India
*Corresponding author, email: naveennigam88@gmail.com

ABSTRACT An irregular sea urchin, *Brissus latecarinatus* (Leske, 1778) Echinoidea Brissidae, is reported herein for the first time from Andaman Islands. A brief description along with a note on its distribution are provided.

KEY WORDS Andaman Islands; *Brissus*; Brissidae; Irregular; Echinoidea; Spatangoida.

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INTRODUCTION

Sea urchins are exclusively marine animals which are found in the sandy and coral reefs areas of the intertidal to the subtidal zones. Sea urchins fall under the Class Echinoidea which is divided in two categories based on their shapes, regular sea urchins and irregular sea urchins. The regular sea urchins possess almost a spherical symmetry and irregular sea urchins are bilaterally symmetrical (Chao, 2000).

In recent times, very few authors contributed to the echinoids in Andaman and Nicobar Islands (Mortensen, 1951; James, 1966; Sastry 2005, 2007; Raghunathan et al., 2013). At present a total of 125 echinoid species are reported from India of which 83 species from Andaman and Nicobar Islands (Clark & Rowe, 1971; Hegde & Rivonker, 2013; Murugan et al., 2016). Till date, only one species of *Brissus* Gray, 1825 (Brissidae) has been described from the Indian waters. *Brissus latecarinatus* (Leske, 1778) is known from the East coast, Lakshadweep and Gulf of Mannar (Bell, 1888; Clark & Rowe, 1971; James, 1983, Sastry, 1991). There has been no collection and description of the irregular sea urchins from Andaman and Nicobar Islands so far. The present paper allows to extend the range of *B. latecarinatus* to Andaman and Nicobar Islands.

MATERIAL AND METHODS

Marine exploratory studies with special reference to Echinodermata have been carried out in two districts viz., North and Middle Andaman and South Andaman (Fig. 1) of the Andaman and Nicobar Islands by employing Self Contained Under water Breathing Apparatus (SCUBA) in depths ranging from 10–30 m. Specimens were collected by hand picking and preserved in dry condition. The preserved specimens were examined under stereozoom microscope (Leica M 205 A) and measurements were taken using a Vernier caliper (Aerospace 150 mm). The identification was based on morphological characters given in Clark & Rowe (1971) and Chao (2000). All the identified specimens are deposited in the National Zoological Collection at the Zoological Survey of India, Andaman and Nicobar Islands.

ABBREVIATIONS. t.l.= total length; t.w. = total width; t.h.= total height.

RESULTS

Systematics

Classis ECHINOIDEA Leske, 1778
Ordo SPATANGOIDA L. Agassiz, 1840
Familia BRISSIDAE Gray, 1855
Genus *Brissus* Gray, 1825

Brissus latecarinatus (Leske, 1778) Figs. 2–7

EXAMINED MATERIAL. One specimen, Casurina Bay (Lat: 13°14.262'N, Long: 92°50.491'E), North and Middle Andaman, depth 10 meter, 23.V.2016, (Reg. No. ZSI/ANRC-16124); one specimen, Laxmanpur (Lat: 11°50.712'N, Long: 93°00.855'E), Neil Island, South Andaman, depth 15 meter, 6.X.2016, (Reg. No. ZSI/ANRC-16125); one specimen, Sunset Point (Lat: 11°50.470'N, Long: 93°01.159'E), Neil Island, South Andaman, depth 15 meter, 7.X.2016, (Reg. No. ZSI/ANRC-16126).

DESCRIPTION. Test oval and white in color. Test medium in size t.l./t.w./t.h.= 34/29/18 mm, outline from above curved, without distinct frontal notch, posterior side narrow and posterior end pointed. The pore series of frontal ambulacrum is not petaloid. Posterior interambulacrum distinctly raised and keeled like. Posterior end obliquely truncate, sloping toward dorsal side. The apical disc well developed with 4 genital pores, posterior petals longer than anterior petals. Petals suken, narrowing proximally and anterior to pore series of anterior petals, series of posterior petals slightly billowy, anterior petals pore pair narrower than posterior pore. Phyllodes long and well developed. Sternal system broad, labrum longer thickened and impenetrable, peripetalous fasciole well developed. Subanal fasciole bean shaped. Periproct longitudinally oval denuded.

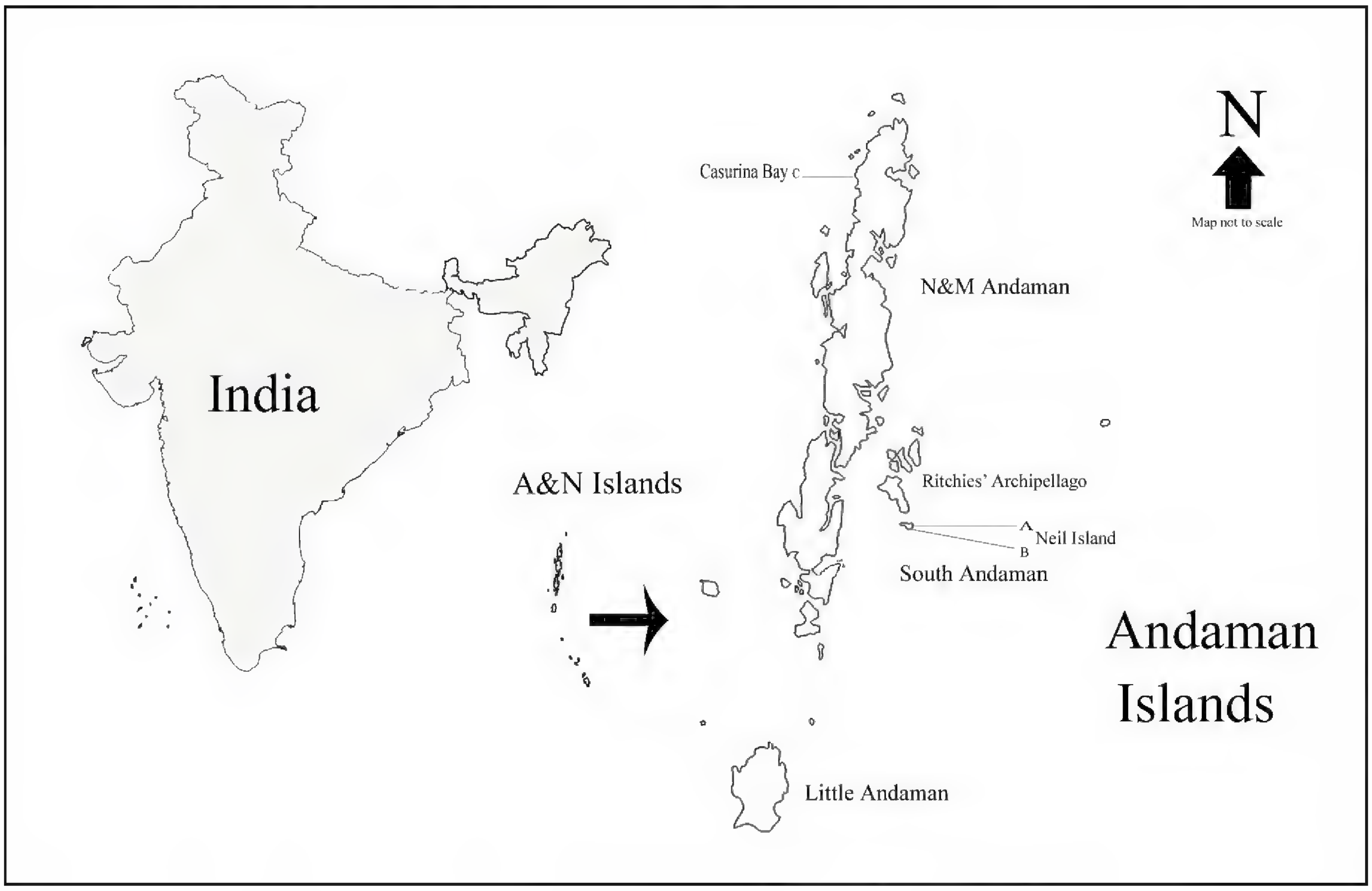
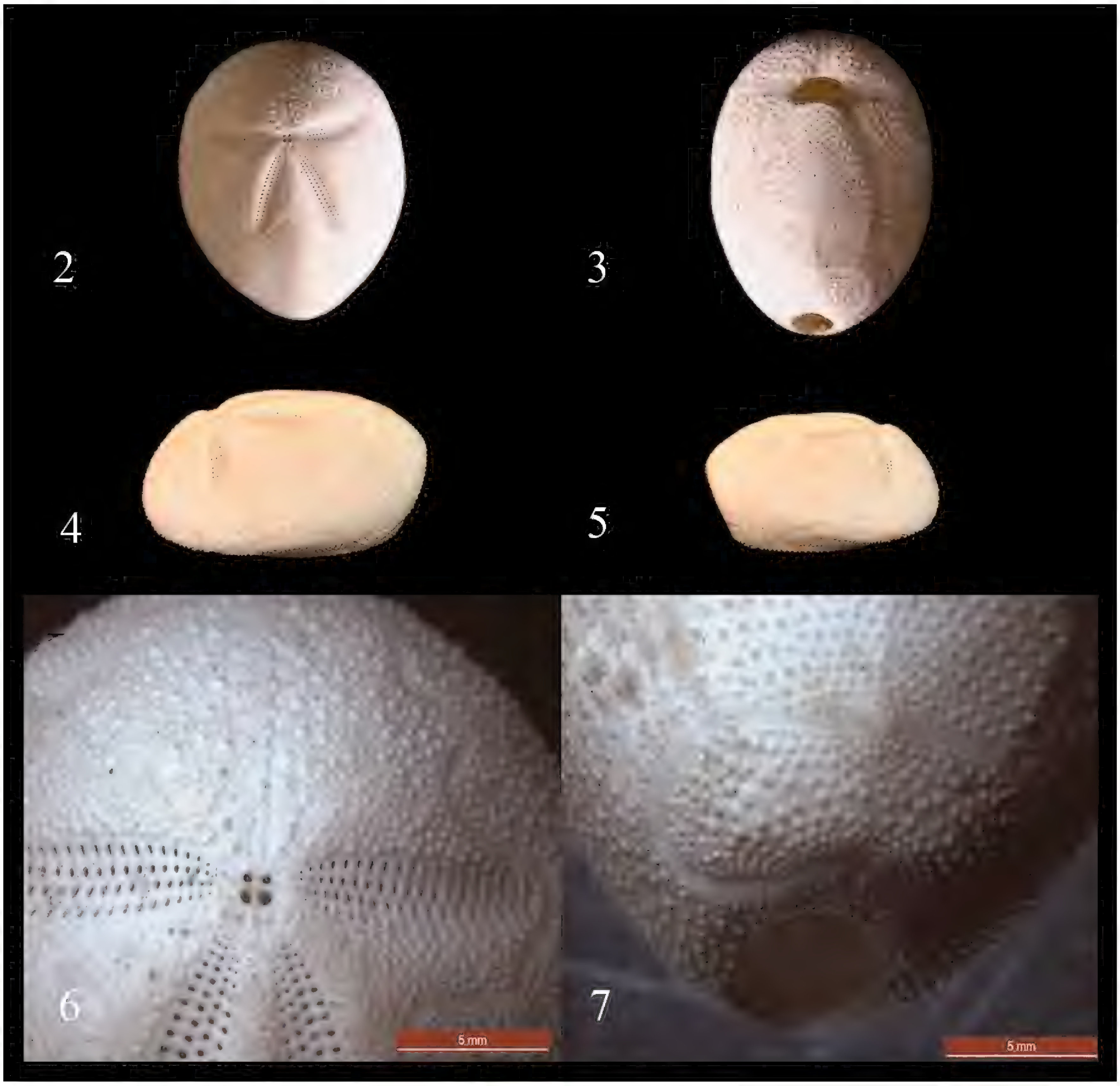


Figure1. Map showing localities of *Brissus latecarinatus* in Andaman Islands. A: Laxmanpur, Neil Island, South Andaman. B: Sunset Point, Neil Island, South Andaman. C: Casurina Bay, North and Middle Andaman.



Figures 2–7. *Brissus latecarinatus* from the Andaman Islands. Fig. 2: aboral view. Fig. 3: oral view. Fig. 4: lateral views (left side). Fig. 5: lateral views (right side). Fig. 6: pore-series of frontal ambulacrum, petals. Fig. 7: view of subanal region and periproct.

DISTRIBUTION AND BIOLOGY. *Brissus latecarinatus* has been reported from the West Indian Ocean, Mascarence Island, East Africa and Madagascar; Maldive; Ceylon; East Indies; North Australia; Philippine Island; China; Japan; South Pacific Island; Red Sea (Clark & Rowe, 1971) Kenya (Humphreys, 1981), Aldabra (Clark, 1984), Northwestern Australian (Marsh & Marshall, 1983), Australia (Rowe & Gates, 1995), East Coast of Africa to Hawaiian Islands (Sastry, 1991), Hawaii Islands (Edmondson, 1946; Clark & Rowe, 1971), Easter Island (Fell, 1974), Gulf of Thailand (Latypov, 2013), Mexico (Martínez-Melo et al., 2016).

This species is exclusively available in subtidal zone, sandy substrates, and corals reefs areas.

REMARKS. New record to Andaman and Nicobar Islands. *Brissus latecarinatus* was previously known from the mainland India (East coast, Lakshadweep and Gulf of Mannar) and hitherto not known from these Islands so far. From Lakshadweep, Bell (1888) reported *B. unicolor* (Leske,

1778) but James (1983) identified *B. unicolor* as a *B. latecarinatus* however, the reasons behind such a change were not mentioned by James. In 1989, James collected a test of sea urchin and identified it as a *B. latecarinatus* from Lakshadweep (Agatti Island) but without poviding a formal description. The present report of *B. latecarinatus* from the Andaman Islands stresses the significance of intensive studies for precise documentation of the echinoid diversity and distribution in the Islands.

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Biodiversity Journal, 2017, 8 (1): 19–20

Water Pipit *Anthus spinoletta spinoletta* (Linnaeus, 1758) (Aves Motacillidae) actively feeding on small fishes

Arnaldo Camilloni[1], Raffaele Luca[2], Roberto Casalini[3] & Andrea Corso[4*]

[1]Via Antonio Rosmini 5, 00033 Cave, Rome, Italy; email: arnaldocam@alice.it
[2]Via Morino 78, 00033 Cave, Rome, Italy; email: raffo1265@gmail.com
[3]Museo Civico di Zoologia, Via Ulisse Aldrovandi 18, 00197 Rome, Italy; email: roberto.casalini@comune.roma.it
[4]Via Camastra 10, 96100 Siracusa, Italy; email: zoologywp@gmail.com
[*]Corresponding author

ABSTRACT In this paper, the Authors observed and photographically documented some Water Pipits *Anthus spinoletta spinoletta* (Linnaeus, 1758) (Aves Motacillidae) feeding on alive small fishes, *Aphanius fasciatus* (Valenciennes,1821) of the Cyprinodontidae family, at Pantani dell'Inferno, Circeo National Park (Lazio, Italy).

KEY WORDS Circeo National Park; ecology; Water Pipit.

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INTRODUCTION

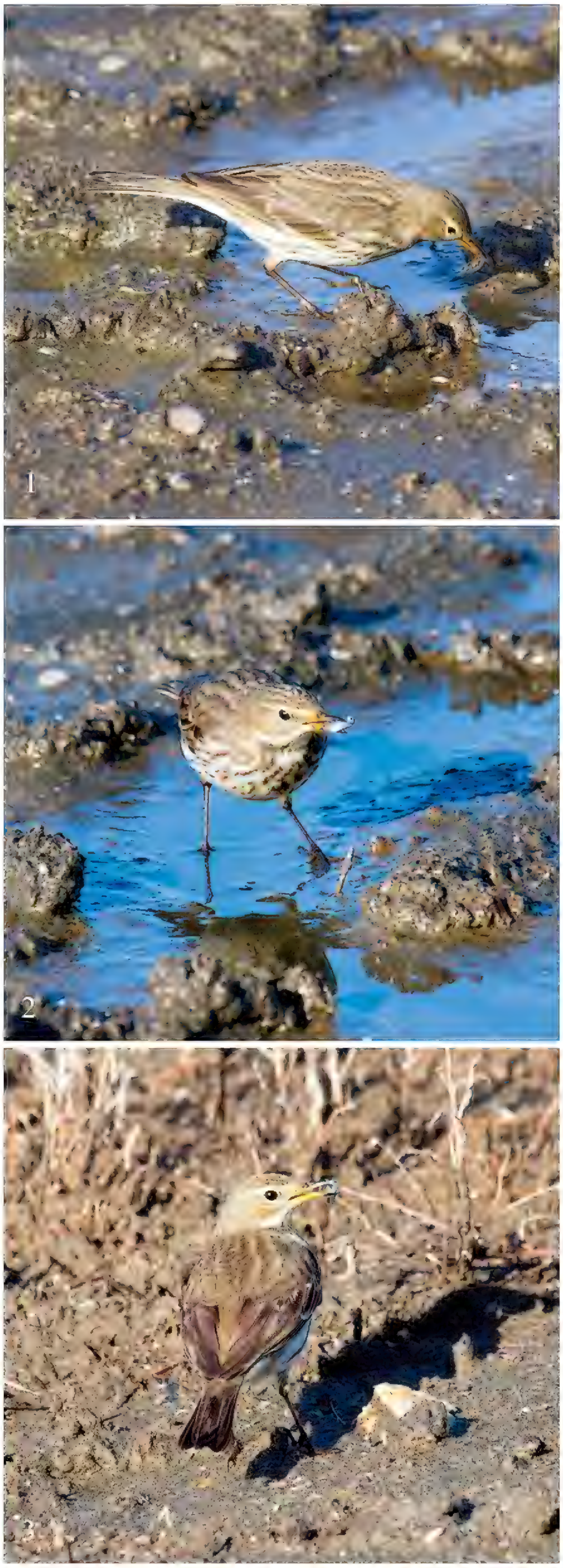
During December 2016, two of us (ACa, RLu) repeatedly observed some Water Pipits *Anthus spinoletta spinoletta* (Linnaeus, 1758) (Aves Motacillidae) feeding on alive small fishes at Pantani dell'Inferno, Circeo National Park (Lazio, Central Italy). The birds walking in very shallow water, actively sought small fry, which were caught and swallowed entirely. The observation was repeated in several occasion and photographically documented. Despite this passerine winters regularly all over the Italian Peninsula, as being also a breeding species and partial migrant, such a behaviour was never recorded before anywhere in the country.

For that reason, we believe is of interest reporting now our observations.

RESULTS AND CONCLUSIONS

From mid to late December 2016, regular visits to the shallow, brakish retrodunal ponds of the wetlands complex of Circeo National Park (Latina, Lazio, Italy), in the locality called Pantani dell' Inferno, gave the opportunity to observe several Water Pipits at very close range, therefore obtaining a number of close up photographs.

Once the last two authors of this short note (RC and ACo) received the photographs, realised that the catching of alive fishes by the species was something probably never reported before or at least rather unusual. The small fry were identified as Mediterranean Killifish or South European Toothcarp *Aphanius fasciatus* (Valenciennes,1821), a fish of the Cyprinodontidae family, endemic to the Mediterranean basin, where it is found in most countries but the Iberian Peninsulan (Bianco, 1995; Duchi & Maino, 2013). Its natural habitats are saline lakes, brackish marshes, and coastal saline lagoons or salt-pans (Bianco, 1995; Leonardos, 2008; Lo Duca & Marrone, 2009). Both Glutz von Blotzheim & Bauer (1985) and Cramp (1988) report only occasional feeding on dead fishes found



Figures 1–3. *Anthus spinoletta spinoletta* fishing and eating *Aphanius fasciatus* at Pantani dell'Inferno (Lazio, Italy) (Fig. 1 by A. Camilloni; Figs. 2, 3 by R. Luca).

along bank shores, while Alström et al. (2003) mention fishes as prey for some Motacillidae, without further information on which species. However, Fikkert (2013) reports the first and so far the previously only known case of fishing Water Pipit, concerning a single bird observed in the Netherlands, catching, killing and eating fishes. This author, mentions the killing of 16 small fishes, with a length of about 4 cm each, identified as belonging to three species: Eurasian Perch *Perca fluviatilis* (Linnaeus, 1758), Sunbleak *Leucaspius delineatus* (Heckel, 1843) and Nine-spined Stickleback *Pungitius pungitius* (Linnaeus, 1758).

Our observations regard seven fishes rapidly molested and eaten by the Water Pipits, and constitute, up to date, the second ever published evidence of fish-eating and the first regarding the Mediterranean area.

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Proliferation and exopolysaccharide production of *Azotobacter* in the presence of mercury

Reginawanti Hindersah[1*], Oviyanti Mulyani[1] & Rafael Osok[2]

[1]Department of Soil Science Faculty of Agriculture Universitas Padjadjaran, Jalan Raya Bandung-Sumedang Km 21 Jatinangor 45363, Indonesia
[2]Department of Soil Science Faculty of Agriculture Universitas Pattimura, Jalan Ir. Putuhena Kampus Poka Ambon, Indonesia
[*]Corresponding author, email: reginawanti@unpad.ac.id

ABSTRACT

Bioremediation is a cheap, easy and effective method to improve the quality of heavy metal-contaminated agricultural land. Plant Growth Promoting Rhizobacteria recently has been proposed to be used in bioremediation of heavy metal. Rhizosphere-inhabitant *Azotobacter* produce exopolysaccharide (EPS) as a mechanism to avoid heavy metal poisoning; and in other hand EPS mobilize heavy metals in soil. The objective of this study was to get an information about growth and exopolysaccharide production profile of *Azotobacter* in media with and without mercury chloride. The bacteria were isolated from mercury-contaminated tailing at gold mining area in Maluku Province; and cultured in liquid medium containing 5, 10, 15 and 20 mg/L of $HgCl_2$. Cultures were incubated for 4 days at 115 rpm on gyratory shaker at room temperature. The results showed that all three isolates of *Azotobacter* enabled to grow in media with lower level of $HgCl_2$ but *Azotobacter* Buru-1 and Buru-2 did not grow on media with 20 mg/L of $HgCl_2$. *Azotobacter* bd3a was able to grow on media with 20 mg/L of $HgCl_2$ although the cell density was lower than that of control and lower level of mercury. The presence of mercury affected and generally suppressed the production of EPS; but the effect depend on the isolates. *Azotobacter* Buru-2 produced more EPS at 2 and 4 days after incubation in the presence of 20 mg/L of $HgCl_2$.

KEY WORDS Agricultural land; *Azotobacter*; Bioremediation; Mercury.

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INTRODUCTION

Illegal gold mining at Buru Island in Maluku Province, Indonesia produced million ton of tailing with low soil fertility and containing mercury since gold extraction was done with amalgamation process. Currently mercury-contaminated tailings was disposed improperly at gold mining site and agricultural areas. The relatively cheap, easy and effective way to reduce levels of mercury in agricultural land is bioremediation. The best way to reduce levels of heavy metals is increased mobility and availability of heavy metals in order to be more easily uptaken by plant accumulators of heavy metals. Recently Plant Growth Promotion Rhizobacteria (PGPR) has been developed as a bioremediation inoculant. *Azotobacter* is heterotrophic aerobic PGPR which are responsible for plant growth through non-symbiotic nitrogen fixation and phytohormone production.

One of EPS-producing microbes that potentially may be developed for the bioremediation of mercury-contaminated soil through the mechanisms of absorption is *Azotobacter*. Exopolysccharide (EPS), an outer cell structures associated with the cell wall, is an important substance and has been known to have a real effect on the adsorption of metal (Prasad et al., 2014). The capacity of *Azotobacter* in synthesizing EPS has been widely reported (Vermani et al., 1997; Hindersah & Sudirja, 2010; Gauri et al., 2012). Exopolysaccharide is an extracellular polymer that can control mobilization of heavy metals (Chen et al., 1995; Hindersah et al., 2007; Micheletti et al., 2008). Exopolysaccharide production was mainly determined by the isolates and the presence of carbon and nitrogen available (Vermani et al., 1997; Hindersah & Sudirja, 2010). However, the production of EPS can be inhibited or induced by the presence of heavy metals such as although *Azotobacter* has been reported as soil bacteria that is resistant to mercury (François et al., 2011).

In the process to screening potent PGPR to remediate mercury-contaminated soil in Buru Island, some *Azotobacter* isolates have been isolated from tailing disposed on productive soil around gold mining area in Gunung Botak, Buru Regency. The bare tailings contain 10-306 mg/kg of total mercury deposited during three years mining from 2012–2105. The average total mercury concentration in agricultural land nearby mining area was 0.1–5 mg/kg which is normal for the soil formed for parent material containing no cinnabar, an more of mercury. This research was conducted to obtain the growth and EPS production profile of *Azotobacter* in the liquid media in the presence of mercury chloride. In the future, this *Azotobacter* will be used as bioremediation agent to decrease either total or available mercury level in tailing disposed on productive paddy soil.

MATERIAL AND METHODS

The study was conducted from May to June 2016 in Soil Biology Laboratory, Faculty of Agriculture, Universitas Padjadjaran. Source of isolates were mercury-contaminated tailings in the gold-mining area at District of Wamsait, Buru Regency, Maluku Priovince. *Azotobacter* isolates Buru-1 and Buru-2 isolated from the tailings contain 10 mg/kg of total mercury while *Azotobacter* bd3a was isolated from tailings containing 306 mg/kg of total mercury.

Three isolates of *Azotobacter* each were grown in a liquid medium described by Vermani et al. (1997) which contains 10 g sucrose, 1.0 g KH_2PO_4, 1.0 g $MgSO_4.7H_2O$; 0.5 g NaCl; 0.1 g $CaCO_3$; 0.1 g $NaNO_3$; 0.1 g $FeSO_4$; 10 mg Na_2MoO_4; 15 g agar; 1 L aquadest at pH 7, without and with 0, 5, 10, 15, and 20 mg/L of L $HgCl_2$. As many as 1% of pure cultures of *Azotobacter* on N-free media at a density of 108 cfu/mL was added into 25 mL of Vermani's liquid medium in the 100 mL erlenmeyer. Incubation was done on gyratory shaker with 115 rpm at room temperature for three days. Cell density of *Azotobacter* was measured every day for three consecutive days. Exopolysaccharide concentration in culture were analyzed at 2 and 4 days after incubation according to the method described by Vermani et al. (1997) modified by Hindersah & Sudirja (2010).

Bacterial cell density was determined by the Dilution Plate Method on Vermani's agar medium. The plates were incubated for 48 hours before the clear, convex and slimy *Azotobacter*'s colony were count. Exopolysaccharide production was determined by gravimetric, a total of 20 ml bacterial culture was centrifuged 9,000 rpm at 4 ^{0}C for 20 minutes; 10 mL of the supernatant was added with 20 mL of cold acetone and left overnight at 4 ^{0}C prior to centrifugation at 9,000 rpm at 4 ^{0}C for 20 minutes. Exopolysaccharide in the bottom of the tube was transferred to a Whatman no. 1 filter paper and heated at 35 ^{0}C for 1 hour and placed into a desiccator for 20 minutes before it was weighed. Acidity measurement was done by using potentiometer at room temperature; by dipping the electrode in bacterial liquid culture until a constant pH value.

RESULTS AND DISCUSSION

Viability of **Azotobacter** *in liquid media in the presence of mercury*

In this experiment, three isolates were cultured on liquid media both with and without mercury. The concentration of $HgCl_2$ were 5,10,15 and 20 mg/L equivalent to 3.7; 7.4; 11.1 and 14.8 mg/L mercury. All three isolates demonstrated the ability to live and proliferate on mercury exposure conditions expect Buru1 and Buru2 in higher mercury concentration (Table 1).

***Azotobacter* Isolates**	**$HgCl_2$ (mg/L)**	**Cell density (CFU)** **Day 1**	**Day 2**	**Day 3**
Buru 1	Control	55,000	820,000	11,900,000
	5	44,000	730,000	10,800,000
	10	22,300	410,000	4,500,000
	15	8,100	110,000	1,230,000
	20	0	0	0
Buru 2	Control	101,000	1,460,000	18,100,000
	5	98,000	1,330,000	17,200,000
	10	11,000	152,000	1,900,000
	15	4,200	67,000	700,000
	20	0	0	0
Bd3a	Control	98,000	1,480,000	17,900,000
	5	97,000	1,120,000	11,100,000
	10	77,000	960,000	10,300,000
	15	49,000	138,000	18,200,000
	20	28,000	350,000	480,000

Table 1. Effect of mercury chloride *Azotobacter* cell density in liquid culture after three days incubation with some level of mercury.

There was an increase of cell density from day one to day three after incubation. Comparing to control treatment, a clear decline in population was shown by all isolate cultured in medium with 15 mg/L and 20 mg/kg of mercury; isolate Buru-1 and Buru-2 did not grow in media with 20 mg/L of mercury. Decrease in mercury level caused decline in cell density especially in day three after incubation, explained that mercury has interfered with the metabolic system of *Azotobacter* especially Buru-1 and Buru-2. Isolates bd3a was more resistant to $HgCl_2$ at concentration of 15 and 20 mg/kg compared to another isolate. Cell of *Azotobacter* bd3a proliferated in liquid media with higher level of mercury although slower than cell proliferation in lower level of mercury and control treatment (Table 1).

Soil polluted by elevated levels of heavy metals caused negative effect on the activity of microbe and their diversity. According to Robinson & Tuovinen (1984), mercury resistant bacteria can be isolated not only from the location of mercury contaminated soil but also of sediment, waste oil and clinic or hospital. Bacterial resistance to mercury and mercury-containing organic material is determined by a plasmid, a small circular DNA molecules, which also encodes resistance to heavy metals and antibiotics. For example Actinobacteria is one of the bacteria that can reduce Hg (2+) to Hg (0) facilitated by the mercuric reductase (MERA); and plays an important role in biogeochemical cycles mercury in temperate environments (Møller et al., 2014).

Azotobacter resistance on mercury is also mediated by activity of mercury reductase and organomercury lyase which decreases the toxicity of mercury. *Azotobacter* can extend the phase lag with the presence of 10–50 mol/L of $HgCl_2$ and Nitrogen fixation capacity slightly inhibited when the bacteria were incubated with 10 mol/L of $HgCl_2$(Ghosh et al., 1996). Resistant *Pseudomonas*, *Cronobacter* and *Bacillus* bacteria detoxified mercury up to 95%; it was shown that *Cronobacter* species are the most efficient in eliminating mercury in NFB medium (Rafique et al., 2015).

Exopolysaccharide Profile

Production of exopolysaccharide (EPS) by three isolate of *Azotobacter* in Vermani's media with or without mercury is shown in Fig 2. The presence of mercury influenced and generally suppressed production of EPS; but the effect depends on *Azotobacter* isolates. On day two, in general, the presence of mercury increased the concentration of EPS, but at 4 days after incubation there was a decrease in the production of EPS.

In general, EPS production of buru-1 and bd3a were significantly low compared to that of control, especially on day four. Two days after incubation the production of EPS of buru-2 with 20 mg/L of mercury was approximately 2-fold compared to control (Fig. 1). However at 4 days after incubation, the production of EPS of buru-2 decreased up to 50% in the presence of 20 mg/L of $HgCl_2$ (Fig. 2).

The presence of mercury in the media induced the production of EPS since bacteria develop mechanisms to avoid heavy metal poisoning. Exopolysaccharide can adsorb heavy metals before it is entering the system of metabolism. Mercury exposure for 4 days substantially reduces the concentration of EPS compared to the EPS production of *Azotobacter* in mercury-free medium (Fig 1).

The effect of Mercury on the synthesis of EPS by *Azotobacter* is reported elsewhere. EPS is formed to withstand drought, environmental stress, and especially to protect nitrogenase from oxygen (Sabra et al., 2000). Gupta & Diwan (2016) described that the establishment of bacterial EPS on the cell surface was to avoid heavy metal toxicity. Exopolysaccharide is one of the outer structure of prokaryotic and eukaryotic microbial cell; in the form of capsules or secreted as mucus that is not strongly attached on the cell surface (Prasad et al., 2014). Exopolysaccharide is a ligand that binds to metals through hydroxyl and carboxyl (Chen et al., 1995; Janecka et al., 2002) to facilitate the mobilization of heavy metals that can be absorbed by plants.

François et al. (2011) have successfully identified a bacterial EPS production in sludge and water

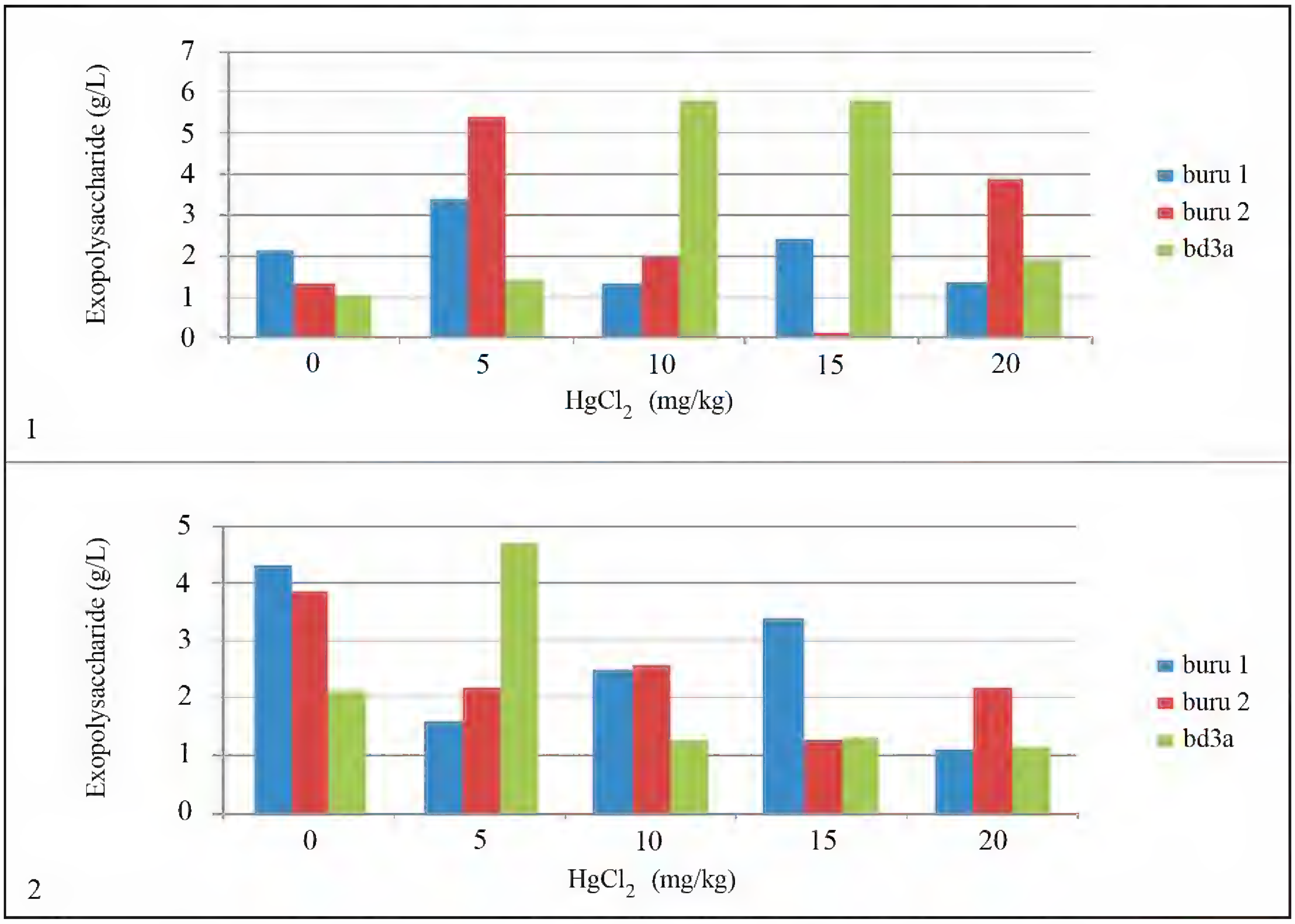

Figure 1. Effect of mercury on the Exopolisaccharide of three isolates of *Azotobacter* in liquid media with and without $HgCl_2$ on two (a) and four (b) days after incubation.

that can proliferate in media with some levels of mercury. Depending on the species, mercury can be extracted from biomass after cultured on media with mercury, showing that bacteria adsorb mercury. Exopolysachharide synthesis is also a natural mechanisms associated with antibiotics (François et al., 2011). For soil microbes, Microbial EPS is one of important substances which has a significant role in facilitating the improvement of soil pores, increasing the root adhering soil and also nutrient uptake especially of nitrogen (Alami et al., 2000). Such mechanism would be an important reason to use *Azotobacter* in bioremediation. *Azotobacter* might have a dual role; first as PGPR that promote growth through nitrogen fixation and phytohormone production and second as bioremediation agents through the production of EPS.

CONCLUSIONS

The results showed that all three isolates of *Azotobacter* were able to proliferate in liquid culture contaminated with mercury. *Azotobacter* was able to grow in media with $HgCl_2$ up to 20 mg/L and the production of EPS depends on isolates and mercury level in liquid media. Isolate of bd3a showed a declined growth in media with 20 mg/L of $HgCl_2$. The presence of mercury affected and generally suppressed the production of EPS; but the effect depends on the isolates. *Azotobacter* buru-2 was the most efficient un EPS producing on day two and four in the medium with 20 mg/L of $HgCl_2$.

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New locality records of a rare Dragonfly *Gynacantha khasiaca* Maclachlan, 1896 (Odonata Aeshnidae) from India

Arajush Payra[1*], Gaurab Nandi Das[1], Aratrik Pal[2], Debarun Patra[3] & Ashish D Tiple[4]

[1]Department of Wildlife and Biodiversity Conservation North Orissa University, Takatpur, Baripada-757003, Odisha, India
[2]Department of Botany, University of North Bengal, Darjeeling - 734014, West Bengal, India
[3]Department of Molecular Biology and Biotechnology, Tezpur University, Napaam, Assam 784028, India
[4]Department of Zoology, Vidyabharti College, Seloo, Wardha 442104, Maharashtra, India
[*]Corresponding author: arajushpayra@gmail.com

ABSTRACT

Gynacantha khasiaca Maclachlan, 1896 (Odonata Aeshnidae) is a beautiful dragonfly, distributed mainly in South-eastern Asia. During Odonata survey in different parts of North-Eastern and Eastern India from 2014 to 2016, some specimens of this species were observed and photographed from 6 localities. Present record of this species from Purba Medinipur, West Bengal represents its Southernmost distribution in India.

KEY WORDS Aeshnidae; distribution; dragonflies; observation; Purba Medinipur.

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INTRODUCTION

Dragonflies and damselflies (Order Odonata) are the prominent and colorful insects of wetlands with long, slender abdomen, commonly known as aerial predators, hunting by sight. These are mostly found around the vicinity of freshwater habitats like rivers, streams, marshes, lakes and even small pools and rice fields. As predators it plays an important role in wetland and terrestrial food chains. Dragonflies are reliable indicators of overall ecosystem health and also good Biocontrol agents (Andrew et al., 2009; Tiple et al., 2013). Worldwide, 5952 species under 652 genera of odonates have been reported, of which 477 species, 50 subspecies in 142 genera and 18 families are known from India (Subramanian, 2014; Nair & Subramanian, 2014; Kiran et al., 2015; Emiliyamma & Palot, 2016).

Among dragonflies, the genus *Gynacantha* Rambur, 1842 are large in size, pale brown and green in colour and are crepuscular by nature (Fraser, 1936). The genus *Gynacantha* with 92 species is distributed throughout the world, especially in the tropics and subtropics region (Asahina, 1993; Schorr & Paulson, 2016). Among them about 30 species are known from the South-eastern Asia and in India the genus *Gynacantha* is represented only by 13 species (Subramanian, 2014; Khan, 2015a). This distribution range of *G. khasiaca* Maclachlan, 1896 is known from India (Mitra, 2002), Nepal (Vick, 1989) and Myanmar (Fraser, 1936), and possibly Tibet (Martin, 1909), although this record appears to be suspected by Fraser (1936). According to Mitra (2002), Bangladesh has also been included in the range of this species and Recently Khan (2015b) reported the species from Tilagor Eco Park of Bangladesh and confirmed its distribution in Bangladesh.

MATERIAL AND METHODS

The authors have been documenting the Odonata diversity in different parts of Eastern and North-Eastern India from 2014–2016. During the extensive survey random specimen collection of *G. khasiaca* was not adopted, as morphologically this species shows some unique characteristics that can easily differentiate it from other Indian *Gynacantha*. Only one specimen was collected from Ramnagar, Purba Medinipur, West Bengal on 29th September 2015 and photographed, including its anal appendages and Wing Venation were taken with the help of Macro lens. We compared specimen and photographs, with known species of the genus *Gynacantha* and identified with the help of identification keys provided by Fraser (1936).

RESULTS

From the present survey 9 individuals (7 males, 2 females) were observed from 6 localities. Details of the sightings from 6 localities are presented in Table 1. Distributional range of *G. khasiaca* in Southern Asia is showed in figure 1 and morphological characters in figures 2–10.

Among the 9 individuals, we observed one brown morph male and one female, the rest were greenish in colour. This brown morph may be due to their young stage. As this kind of morphological colour changes with respect to aging as observed by Fraser (1936) in the specimens of *Gynacantha dravida* Lieftinck, 1960. In case of old *G. khasiaca* male, eyes are pale blue to olive green in colour. Labrum and labium olive brown in colour. Frons light green with black 'T' shaped mark on its upper side. Thorax is bright green, with two thick blackish brown stripes on each side of it. Legs are mainly black to blackish brown. Wings are hyaline, but at the base of wing tinted with bright amber colour. Pterostigma dark brown in colour and covering 4, 5 cells. Discoidal cells 5 celled in forewing, but in case of hind wing it varies from 4–6 cells. Length of the abdomen is mainly 47–51 mm. Segment 1 laterally green and dorsally brown. Segment 2 is laterally bluish and light green beneath. Segment 3–7 with jugal paired spots and greenish paired apical annule. Segment 8–10 entirely black. Anal appendages black in colour, where inferior anal appendages is two-third the length of the superior

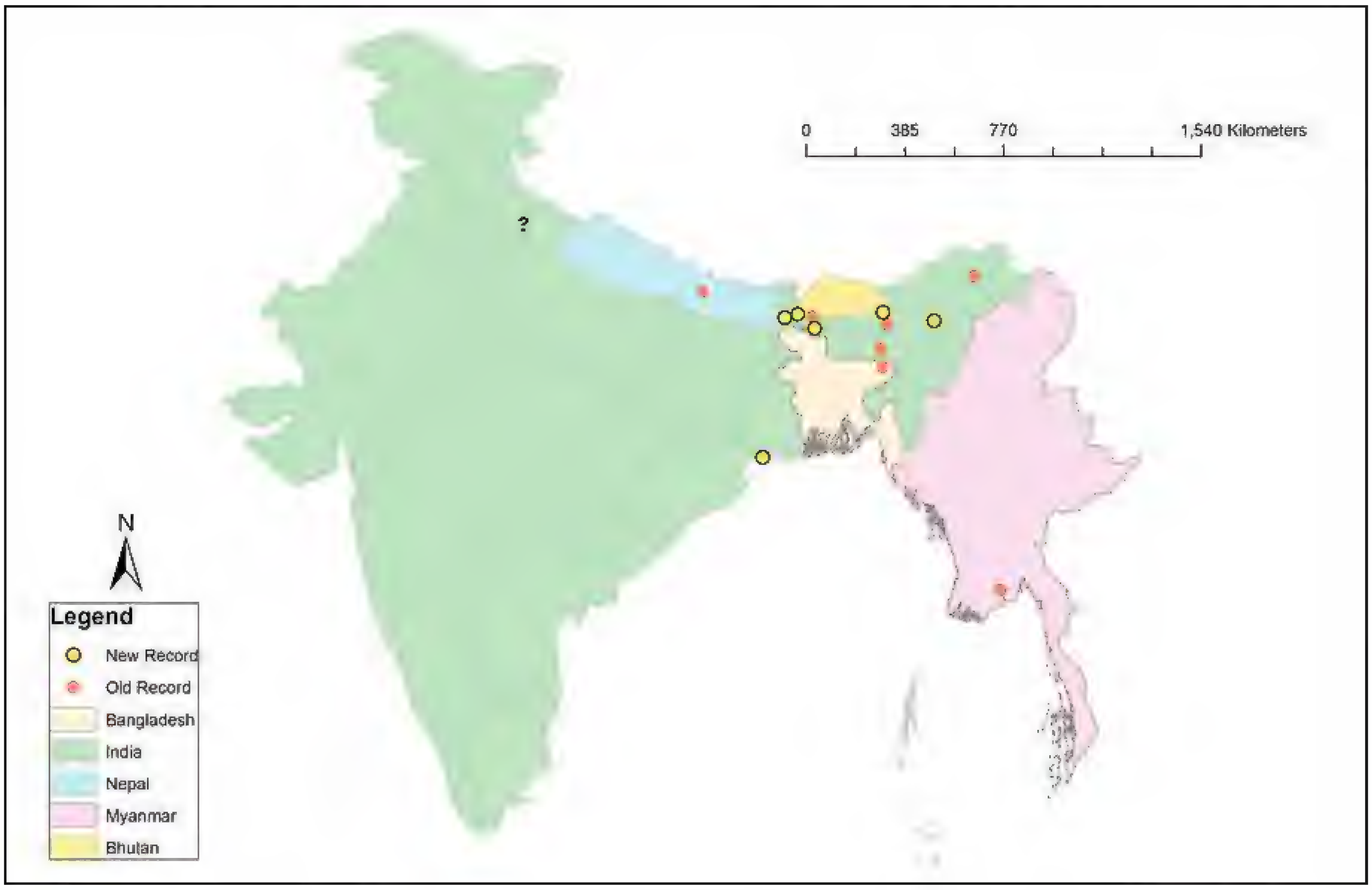
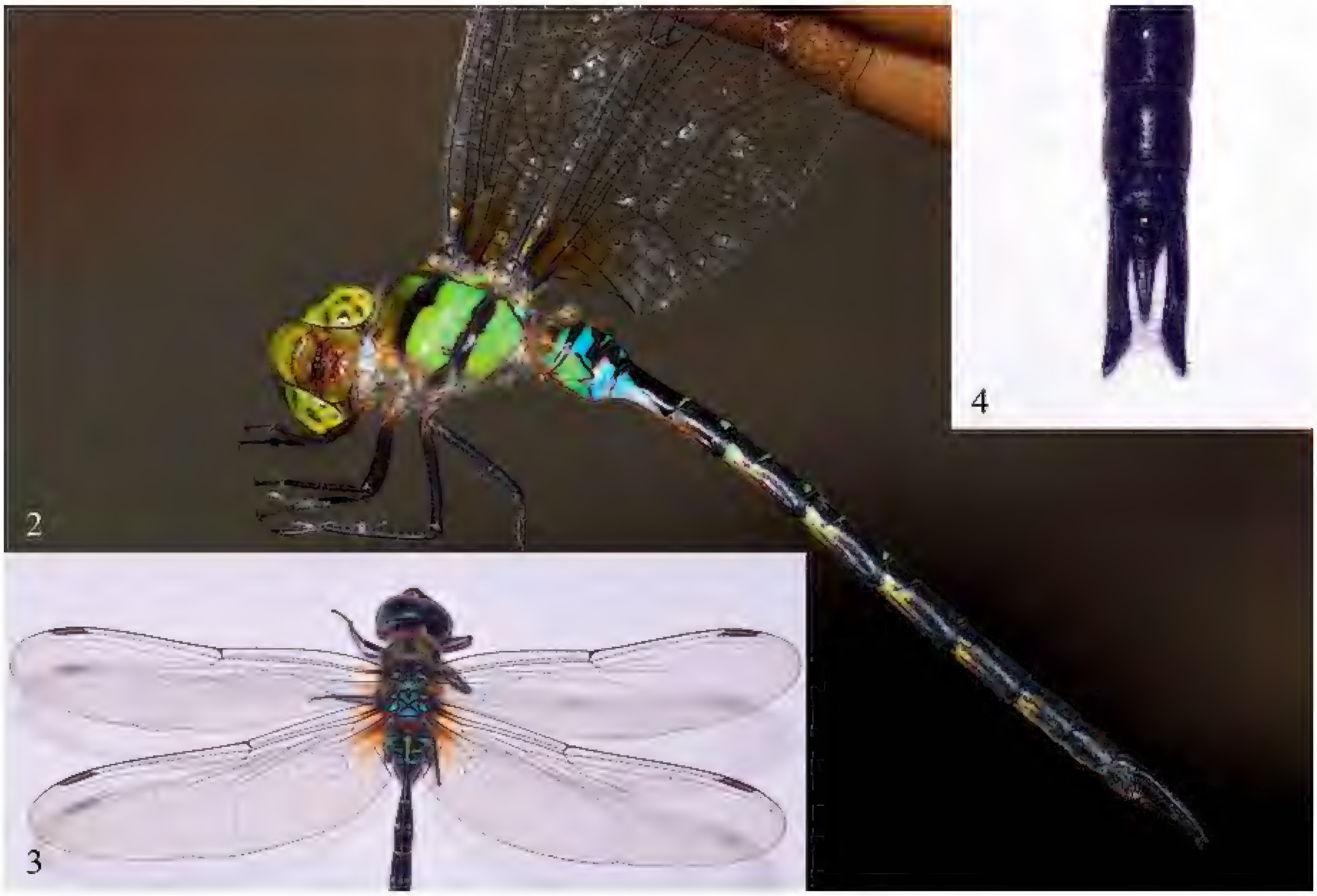


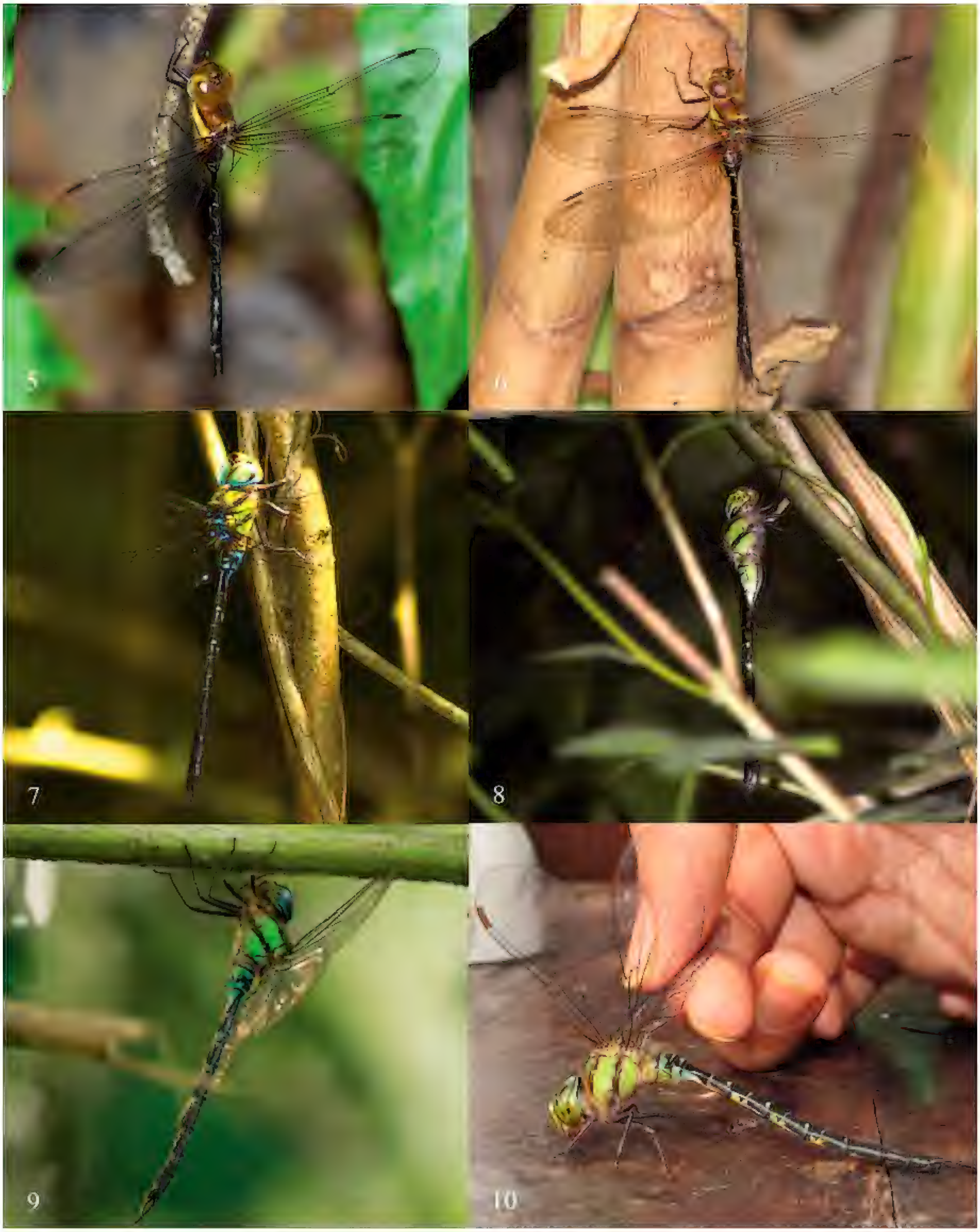
Figure 1. Distributional range of *Gynacantha khasiaca* Maclachlan, 1896 in Southern Asia.

Date and time	Location	Latitude and longitude	Altitude	Sex	Habitat
06.10.2014; 11.45 am	Deo Pahar, Golaghat, Assam	26°35’56”N 93°44’6”E	153 m	Male	Dense forest
18.11.2014; 5 pm	Murti River, Gorumara National Park, West Bengal	26°49’46”N 88°49’58”E	144 m	Male	Dense forest
12.07.2015; 10.17 am	Cooch Behar, West Bengal	26°19’21”N 89°26’48”E	46 m	Female	Human habitation
06.8.2015; 12.27 pm	Siliguri, West Bengal	26°42’21”N 88°22’12”E	125 m	Male	Human habitation
14.09.2015; 12.31 pm	Ramnagar, Purba Medinipur, West Bengal	21°40’19”N 87°34’29”E	7 m	Male	Human habitation
21.09.2015; 13.01 pm	Ramnagar, Purba Medinipur, West Bengal	21°40’19”N 87°34’29”E	7 m	Female	Human habitation
29.09.2015; 18.09 pm	Ramnagar, Purba Medinipur, West Bengal	21°40’19”N 87°34’29”E	7 m	Male	Human habitation
07.10.2015; 18.50 pm	Ramnagar, Purba Medinipur, West Bengal	21°40’19”N 87°34’29”E	7 m	Male	Human habitation
28.10.2015; 18.15 pm	Khalingduar Forest IB, Assam	26.51.43 N 91.52.47 E	377 m	Male	Human habitation

Table 1. Sighting records of *Gynacantha khasiaca* in different parts of Eastern India.



Figures 2–4. *Gynacantha khasiaca* male (Ramnagar, Purba Medinipur, West Bengal; 7.X.2015). Fig. 2: lateral view of the specimen. Fig. 3: wing venation of the specimen. Fig. 4: anal appendages (inferior anal appendages more than half the length of superior anal appendages).



Figures 5–10. *Gynacantha khasiaca*. Fig. 5: *Gynacantha khasiaca* male (Ramnagar, Purba Medinipur, West Bengal, 14.IX.2015): Young male shows brown morph. Fig. 6: *Gynacantha khasiaca* female (Cooch Behar Purba, West Bengal, 12.VII.2015): Young female shows brown morph. Fig. 7: *Gynacantha khasiaca* male (Deo Pahar, Golaghat, Assam, 06.X.2014): dorsal-lateral view. Fig. 8: *Gynacantha khasiaca* female (Ramnagar, Purba Medinipur, West Bengal, 21.IX.2015): lateral view. Fig. 9: *Gynacantha khasiaca* male (Murti River, Gorumara National Park, West Bengal, 18.XI.2014): lateral view. Fig. 10: *Gynacantha khasiaca* male (Siliguri, West Bengal, 06.VIII.2015): lateral view.

anal appendages. Old females are also similar to males except sexual characteristics.

In case of young male eyes are olive brown. Labrum and labium also brownish. Side of the thorax is light yellowish in colour. Base of the wing also tinted with brown amber colour. Dorsal surface of the all abdominal segments blackish brown and beneath pale yellow. Male and female specimens of *Gynacantha* were observed in dense forest area, human habitations with dense vegetation near aquatic bodies at different parts of Eastern and North-Eastern India (see Table 1).

Among the species of the genus *Gynacantha*, *G. khasiaca* is one of most beautiful dragonfly. It can be easily distinguished from other Indian *Gynacantha* by the greater length of inferior anal appendages which is more than half the length of superior anal appendages and two blackish brown stripes on each side of the bright green thorax (Fraser, 1936; Khan, 2015).

DISCUSSION

In India *G. khasiaca* was mainly restricted to North-eastern India and previously known from Meghalaya: Khasia Hills (Fraser, 1922; Kimmins, 1969; MacLachlan, 1896), Assam: Mangaldai (Laidlaw, 1923, Fraser, 1936), Arunachl Pradesh: Abor Hills (Laidlaw, 1914), West Bengal: Cooch Behar (Mitra, 2002) and Hasimara, Duars (Fraser, 1936), in Uttarakhand (Prasad & Sinha, 2010) collection locality is unknown. Presently we observed this species from 6 localities of both Eastern and North-Eastern India. Among them 5 localities are new for this species. The newly observed locality of *G. khasiaca* in Purba Medinipur, West Bengal, India lies approximately 550 km southwest of the Cooch Behar, West Bengal, India and Tilagarh Eco Park, Bangladesh, which are the nearest previously known localities. The observation of this species in Khalingduar Forest IB, Assam is also important as this place is very close to the Bhutan. Hence such new locality records indicate this species may be found in Bhutan as well as in other parts of Peninsular India in a next future. Despite the recent reports of *G. khasiaca* in Bangladesh by Khan (2015b) and in Nepal by Vick (1989), in India the last record of this species was made by Mitra (2002) and the examined specimen was collected in 1983. Therefore our present investigation designates its reports after a long time in India.

With the exception of the observation from Deo Pahar, Assam and Murti River bed, West Bengal; the remaining observed localities were very close to human habitations. During the last decade, the cities have expanded twice in their circumference causing loss of natural habitats for Odonates. Urban development is expected to have a deleterious impact on Odonata populations, if only because the construction of buildings and concretes replaces or reduces the area of natural and semi-natural habitats. The quality of residual habitats may also be adversely affected by various forms of pollutants (Tiple & Chandra, 2013; Tiple & Koparde, 2015). Due to the limited knowledge on distribution, seasonality, low number of known localities and continuous decline of habitats, *G. khasiaca* was categorized as a Data Deficient in IUCN (Mitra et al, 2010). Much work has yet to be done in future to clarify the distribution and status of the species, especially for the purposes of conservation.

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Update to the status of *Pantala flavescens* (Fabricius, 1798) and *Trithemis kirbyi* Selys, 1891 for Italy and Central Mediterranean basin (Odonata Libellulidae)

Andrea Corso[1*], Ottavio Janni[2], Maurizio Pavesi[3 *] & Michele Viganò[4]

[1]MISC, Via Camastra 10, 96100 Siracusa, Italy; e-mail: zoologywp@gmail.com
[2]MISC, Via Ongetta 5, 21010 Germignaga, Varese, Italy; e-mail: mikivigano@yahoo.com
[3]Museo di Storia Naturale, Corso Venezia 55, 20121 Milano, Italy; e-mail: maurizio_pavesi@yahoo.com
[4]MISC, Via G.G. D'Amore 21, 81016 Piedimonte Matese, Caserta, Italy
[*]Corresponding author

ABSTRACT An overview of the records of *Pantala flavescens* and *Trithemis kirbyi* for the Sicilian Channel islands and mainland Sicily, with comments on their possible status in this area, is provided. In light of the number of observed individuals, *P. flavescens* is likely to be regular in the studied area, with up to 30 individuals recorded per year since autumn 2012. *Trithemis kirbyi*, conversely, is only known from few scattered records, so that its status in the area remains to be elucidated. No evidence of reproductive behaviour nor of actual breeding in this area was hitherto found for any of the two species.

KEY WORDS *Pantala flavescens*; Pelagie islands; *Trithemis kirbyi*.

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INTRODUCTION

Pantala flavescens (Fabricius, 1798) (Odonata Libellulidae) is the most widespread dragonfly species in the world, being recorded from all continents but Antarctica. It reaches northwards at least to north-eastern U.S. in North America, and to Kamčatka in eastern Asia, yet its main range is between 40°S and 40°N (Walker & Corbet, 1975). It is an outstandingly resistant, powerful flyer, and a very long distance migrant, often laying eggs during its migrations wherever suitable conditions are found (Boudot et al. 2013). Because of its rapid larval development, it is also able to exploit temporary waterbodies created by seasonal or occasional rains. During migration, the species is capable of very long sea-crossings - up to 1,000 km in a few days - either at night or during daylight (Feng et al., 2006; Anderson, 2009; Hobson et al., 2013; May, 2013; Suhling et al., 2009, 2016; Vieira & Cordero-Rivera, 2015). It has also reached Easter Island, one of the most remote islands in the world, more than 3,500 km from South American coasts, where a breeding population occurs (Dumont & Verschuren, 1991). Despite its highly migratory nature and the wide distribution, records in Europe and North Africa are surprisingly scarce (Jacquemin & Boudot, 1999; Jödicke, 1995; Jödicke et al., 2000; Schrijvershof, 2006; Buczyński et al., 2014). In Africa, *P. flavescens* is commonly found throughout the continent including Madagascar, from the Cape of Good Hope to the southern edge of the Sahara; there are however only a few records north of the Sahara, not recorded e. g. for Libya or Western

Sahara (Boudot et al., 2013). It is more frequent in Egypt and adjacent areas of Asia Minor (Dijkstra & Lewington, 2006; Kalkman & Van Pelt, 2006; Boudot et al., 2009).

Trithemis kirbyi Selys, 1891 (Odonata Libellulidae) is widespread throughout Africa, except in rainforest areas, and in Southern Asia up to India (Dijkstra & Lewington, 2006; Boudot et al., 2009). Unlike *P. flavescens*, *T. kirbyi* is not a regular long-distance migrant, its movements being essentially erratic; yet it has recently and rapidly expanded its range northwards, spreading into south-western Europe (Chelmick & Pickess, 2008; Cano-Villegas & Conesa-García, 2009; Herrera-Grao et al., 2012; Corso et al., 2012; Boudot et al., 2013; Obrégon-Romero et al., 2013). Global warming is influencing the distribution range of numerous species of Odonata, causing northward expansions, while a tendency towards an increasing range of movements in their migratory patterns has noticed as well (Ott, 2001, 2010; Dijkstra & Lewington, 2006; Bernard et al., 2009; Vieira & Cordero-Rivera, 2015). *Trithemis kirbyi* was recorded for the first time in Sardinia in 2003 (Holuša, 2008).

Corso et al. (2012) briefly reported first records of *P. flavescens* for Italy and of *T. kirbyi* for the small Sicilian islands, in view of the present, more detailed report. All the records of the two species for Sicilian Channel islands and Sicily, updated to November 2016, are herewith listed and discussed.

MATERIAL AND METHODS

The study area, shown in figure 1 and figure 2, is represented by:

1) The Pelagie Islands (Isole Pelagie), three small islands - Lampedusa, Linosa, and Lampione - located in the middle of the Sicilian Channel, south of Sicily, halfway between Malta and Tunisia. Geographically and geologically one part of the archipelago (Lampedusa and Lampione) belongs to the African plateau, while Linosa is a volcanic island; politically and administratively the islands fall within the Sicilian province of Agrigento and represent the southernmost part of Italy. The largest island is Lampedusa, about 20 km²; the second largest island is Linosa, while the smallest is the uninhabited Lampione. The vegetation on Lampedusa and Lampione is exceedingly low and scarce, because of extensive destruction of the formerly existing Mediterranean scrub; the latter is better preserved on Linosa. Aquatic biotopes are extremely scarce and scattered, only consisting in a few temporary, rain-fed waterbodies. The maximum altitude of the archipelago is on Linosa, with Monte Vulcano (195 m a.s.l.), followed by Lampedusa, with Albero Sole (133 m a.s.l.).

2) Northwest of the Pelagie there is the volcanic island of Pantelleria, 110 km south-west of Sicily and only 70 km north-east of Tunisia, by far the largest and highest in altitude of the Sicilian Channel islands (836 m a.s.l., ca. 83 km²). Besides having several temporary waterbodies, consisting in man-made water reservoirs and catchments, it has a permanent volcanic lake, with a dense, locally wide reed belt, potentially suitable for several Odonata; because of high salinity, however, only *Ischnura fountaineae* Morton, 1905, with the only known viable European population, is definitely known to breed here, and very few other dragonflies are supposed to do so, at least occasionally.

3) Sicily, the biggest island in the Mediterranean basin, is situated right in the centre of this "closed" sea. It has a great variety of aquatic biotopes, including coastal brackish wetlands, freshwater lentic biotopes (either natural or man-made), streams and rivers, habitats for a lot of Odonata species.

Since 2004, the islands of the Sicilian Channel were visited every year, mainly by AC, OJ and MV. The Pelagie were regularly visited in spring (February–May), summer (June–August), autumn (September–November), with a few winter visits (December–January). Pantelleria, conversely, was visited mainly in spring, with a very few visits in summer and autumn. More specifically, between April 2004 and November 2016, the Pelagie were visited for a total of almost 540 days, mostly during the autumn (see Corso et al., 2012). During these visits, all potentially suitable dragonfly habitats, over as much ground as possible, were prospected, in order to assess what dragonfly species were actually or possibly breeding in local waterbodies, and what were only regular migratories or accidental vagrants. The former ones proved extremely scarce (Corso et al., 2012). Information, although derived from more anecdotal observations, regarding the island of Djerba, Southern Tunisia, Gulf of Gabès, and the Maltese Archipelago are also reported, as these sites are geographically close and

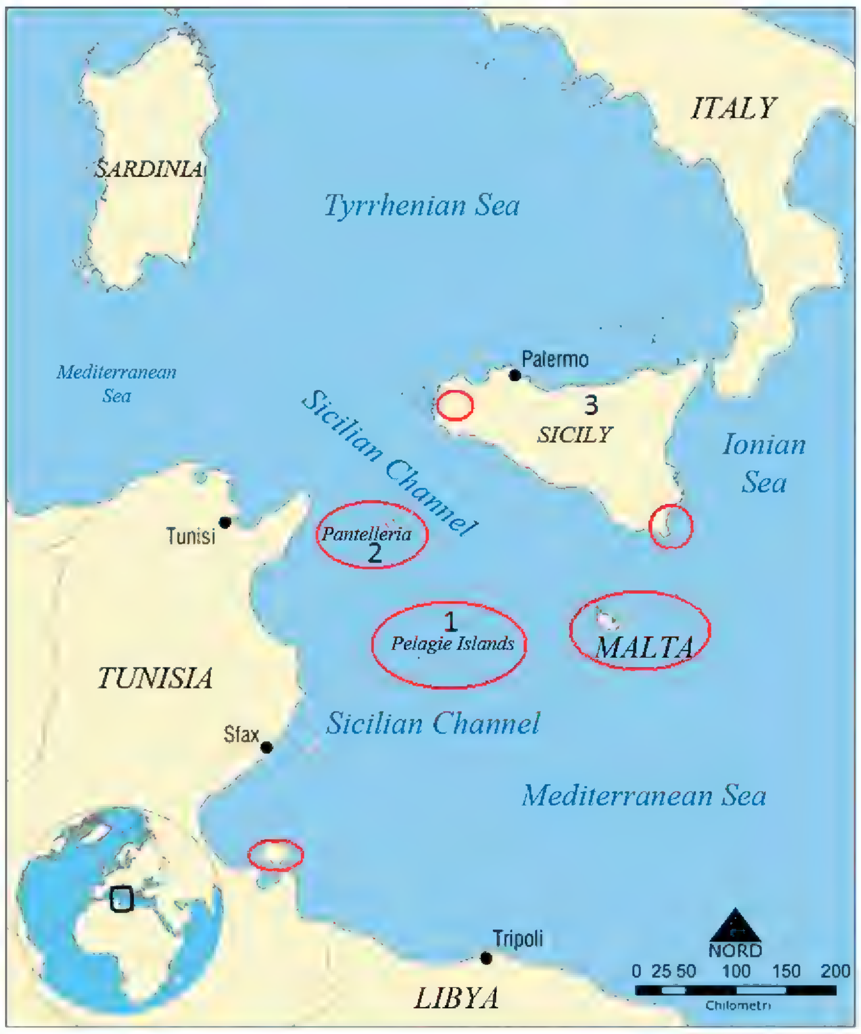


Figure 1. The study area in the Centre of Mediterranean Basin, red circles showing the observations (and/or literature data) sites.

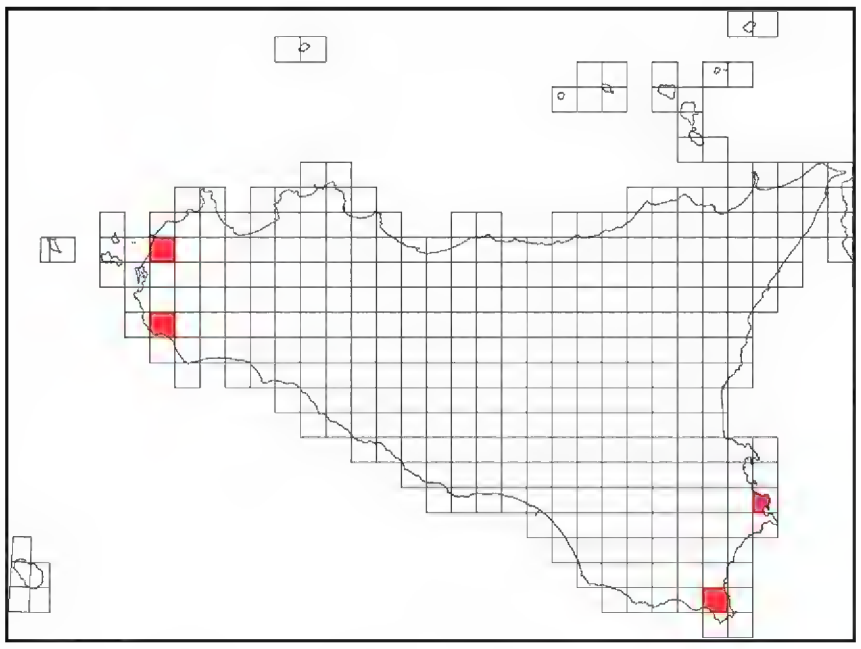


Figure 2. Map of Sicily showing the areas where *Pantala flavescens* was recorded during this study.

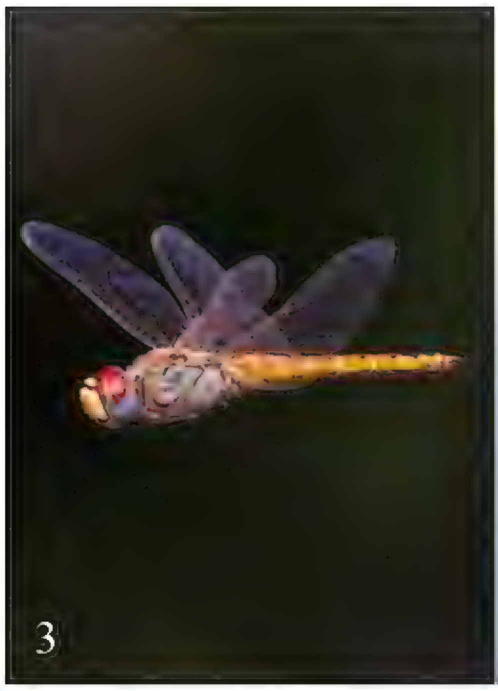
records from these areas are closely associated with the patterns affecting Sicily and Pelagie islands. Most of the records here reported refer to netted or photographed specimens. However, some concern field observations only, since *P. flavescens* and *T. kirbyi* are strong, fast fliers, often quite shy and difficult to catch or approach. Fortunately, both are locally unmistakable, so that their field identification is easy and reliable (Dijkstra & Lewington, 2006). When netted, the specimens were photographed in the hand in four different positions - side view, from below, from above and a close up of secondary genitalia. To photograph the specimens we used a digital SLR camera with a 18–70 mm lens. Only a few voucher specimens were collected, currently housed in the private collections of two of the authors (AC and MP).

RESULTS

Corso et al. (2012) report the first Italian records of *P. flavescens* from the Pelagie on October 2012, with no further details. A detailed list of records is herewith provided.

Lampedusa: 1 ex. (sex?), Cala Morta, 27.X.2012. Linosa: 1 male, 28.X.2012; 1 male, 5.XI.2012; 13 exx. (mostly males), 6.XI.2012; 3 exx. (sex?), 7.XI.12; 8 exx. (mostly males), 8.XI.2012; 2 exx. (sex?), 11.XI.2012 (Figs. 3–5). Both males and females, the formers more abundant, were recorded; all individuals were apparently immature, none of the males showing bright red coloration. Only 1 male, on 6.XI.2012, was collected, and is currently housed in MP collection (Figs. 4, 5). In the following years, *P. flavescens* was regularly recorded on Linosa. At least 15 exx. were noticed from 20.X.2013 to mid XI.2013; at least 8 from late X.2014 to mid XI.2014; in 2015, 1 male was seen on 27.X, 1 on 28.X and 1 on 3.XI; in 2016, only 1 (sex?) on 22.X. Sicily mainland (Fig. 2): the first confirmed record concerns 1 male, Pantano (= marsh) Cuba (Siracusa province), 36°42'27.10"N 15°1'30.40"E, 2.XII.2012, AC (MP coll.). In the following years, further individuals were observed: 1 male, Siracusa, 37°6'37.34"N 15°13'43.28"E, 15.X.2014; 1 male, near Trapani, 37°59'34.18"N 12°31'9.52"E, 20.X.2014; 1 male, near Mazara del Vallo (Trapani province), 37°39'44.25"N 12°32'2.06"E, 18.X.2014; 1 male, Siracusa, in the very same site of the 2014 record, a mall parking area, 19.X.2016 (all by AC). Although the repeated observations on the said parking area may appear surprising at first, the warm asphalted ground could actually prove attractive to wandering individuals.

Because of their relevance to the study area, observations by AC at Djerba island (Gulf of Gabès, Tunisia) are also reported. At least 20 specimens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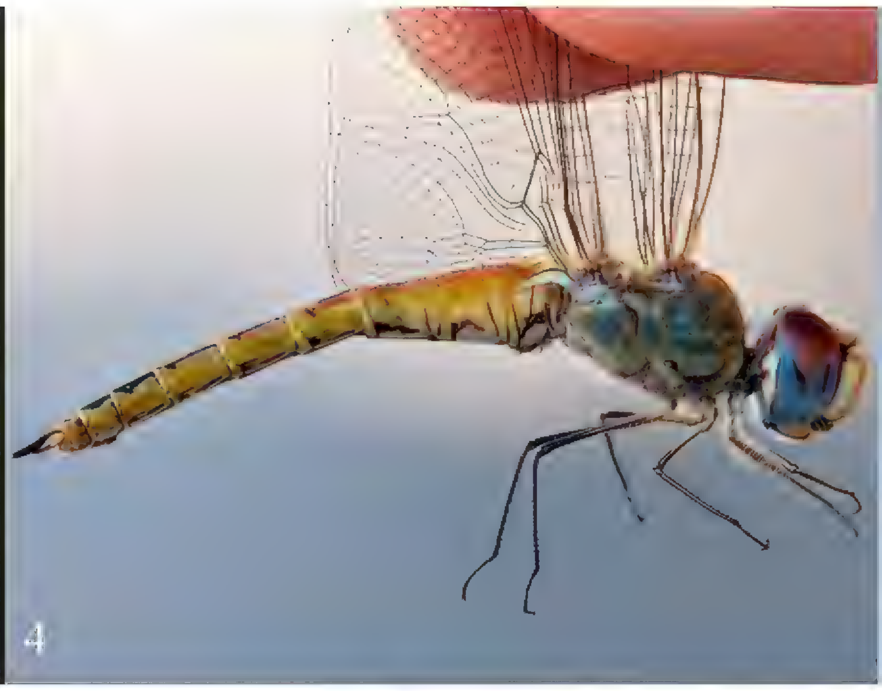
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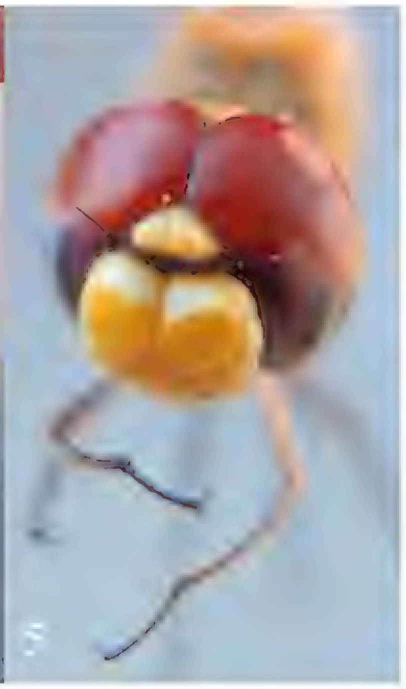
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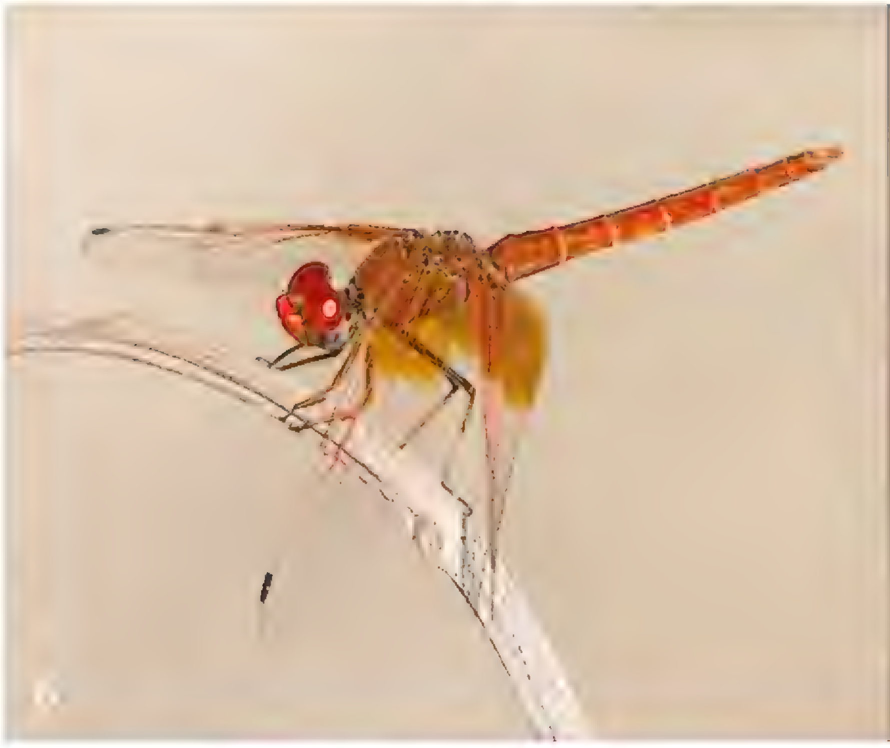
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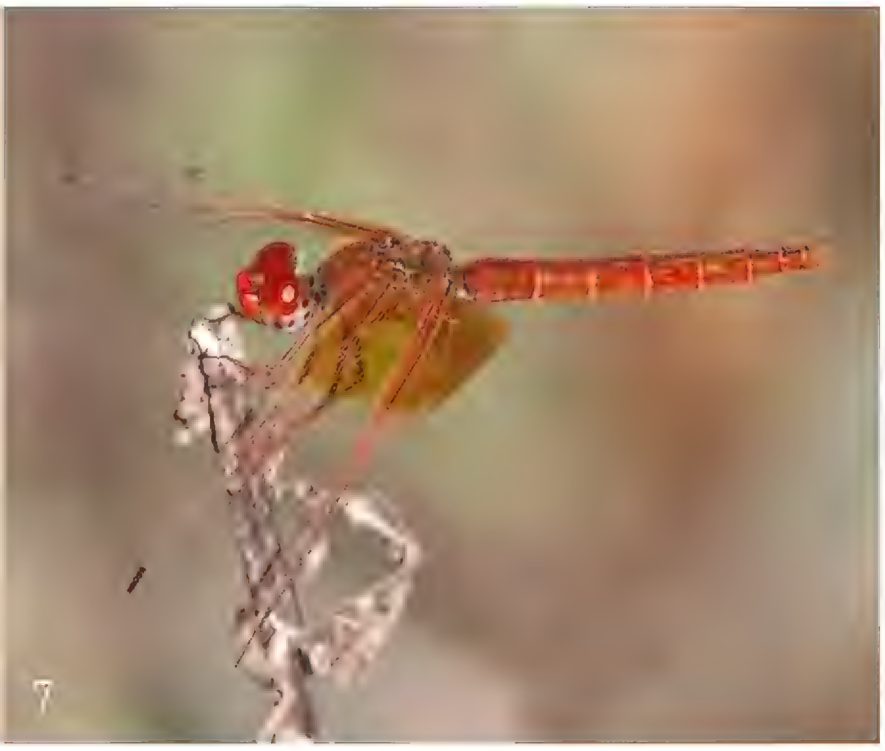
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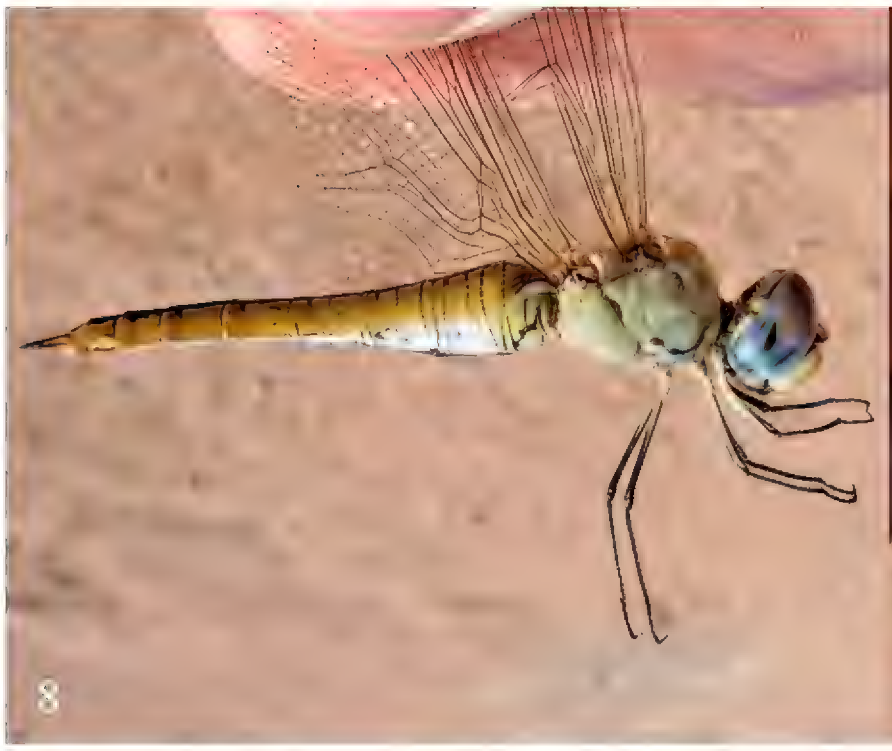
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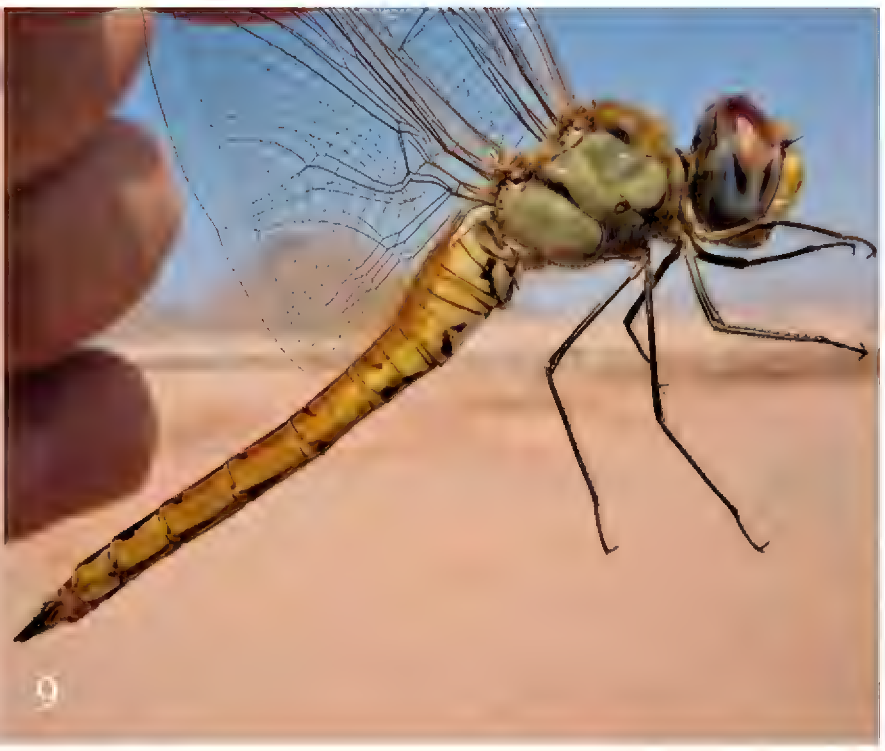
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Figure 3. First photographically documented record of *Pantala flavescens* for Italy, concerning an immature male observed at Linosa Island, Pelagie (Agrigento province, Sicily) on 18.X.2012 (M. Viganò/MISC). Figures 4, 5. The only specimen collected of *P. flavescens* in Italy up to date - 1 male netted at Linosa Island, Pelagie, on 6.XI.2012 (M. Viganò/MISC). Figures 6, 7. The first *Trithemis kirbyi* ever photographed alive in the field for Italy, at Linosa Island, Pelagie, on 16.X.2013 (Igor Maiorano/MISC). Figure 8. A mature female of *P. flavescens* collected in the Sinai desert, Egypt, October 2009, during massive migration, for comparison (A. Corso/MISC). Figure 9. An immature male of *P. flavescens* collected in the Sinai desert, Egypt, October 2009, during massive migration, for comparison (A. Corso/MISC).

(mostly males) were observed on 30.IX.2010, around the water treatment ponds of El Kantara (33°41’52.48”N 10°56’25.45”E), probably the best site for Odonata in the entire island (AC, unpubl.).

In the Maltese Archipelago, the species was recorded in the summer 2013 with three specimens observed/collected (Degabriele, 2014). It is to be stressed that no reason seems to exist, for which migratory *P. flavescens* should not occur also on Pantelleria. Lack of records may only result from no researcher presence on the island during the suitable period.

As for *T. kirbyi*, Corso et al. (2012) provided the second record for Italy, after the first from Sardinia in 2003 (Holuša, 2008), and the first regional one, of a pair observed on Lampedusa, Capo Grecale, 20.X.2012. Subsequent records were obtained. Lampedusa: 1 male observed, Albero Sole, 35°31’40.41”N 12°32’20.04”E, 6.XI.2014. Linosa: at least 6 specimens (3 males, 3 females) 35°52’10.65”N 12°51’49.77”E, 16–20.X.2013, 3 of which (2 males, 1 female) were collected (Figs. 6, 7, AC and MP collections).

CONCLUSIONS

The Pelagie islands are the only European area where the highly migratory *P. flavescens* was recorded regularly through more years (Corso et al., 2012; Buczyński et al., 2014). During this study, up to about 30 specimens were noticed - mostly collected or photographed - on Linosa and Lampedusa every autumn, since the first records by Corso et al. (2012). Some records were also obtained in Sicily mainland, in December 2012 and again in autumn 2014 and 2016. The species was recently recorded also in the Maltese Archipelago (Degabriele, 2014). Upon future studies, *P. flavescens* very likely will prove a regular migrant also here, and on Pantelleria as well. Although the species is a regular migrant also in Sicily mainland, where no doubt a number of suitable biotopes exists, there is at present no evidence of breeding in Italy; this also will be the target of future studies. *Trithemis kirbyi* is widespread and rather common throughout North Africa (Dijkstra & Lewington, 2006; Boudot et al., 2009, 2013) and is at present rapidly spreading in Spain as well (Chelmick & Pickess, 2008; Herrera-Grao et al., 2012; Obrégon-Romero et al., 2013); yet it has only occasionally been recorded in the Sicilian Channel islands, precisely in the Pelagie (Corso et al., 2012), while no record for Sicily mainland currently does exist.

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Chiloneus hoffmanni (González, 1970) (Coleoptera Curculionidae) new to Italy, with a checklist of the species of the genus and ecological notes

Roberto Casalini[1], Enzo Colonnelli[2*], Andrea Corso[3] & David Mifsud[4]

[1]Museo Civico di Zoologia, via Ulisse Aldrovandi, 18, 00187 Roma, Italy
[2]via delle Giunchiglie, 56, 00172 Roma, Italy
[3]via Camastra, 10, 96100 Siracusa, Italy,
[4]Institute of Earth Systems, University of Malta, Msida MSD 2080, Malta
[*]Corresponding author, email: ecolonnelli@yahoo.it

ABSTRACT *Chiloneus hoffmanni* (González, 1970) (Coleoptera Curculionidae) thus far considered a Maltese endemic, is here recorded for the first time from Lampedusa island (Italy). Several adults of this species and of *C. solarii* Pesarini, 1970 were found feeding on leaves of *Charybdis pancration* (Asparagaceae). These observations constitute the first data on the ecology of these species. An updated checklist of *Chiloneus* Schoenherr, 1842 is also provided.

KEY WORDS Curculionidae; *Chiloneus*; diversity; biology; Mediterranean.

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INTRODUCTION

Chiloneus Schoenherr, 1842 is a genus of Sciaphilini Sharp, 1891 (Coleoptera Curculionidae) having a Mediterranean-Turanian distribution. The genus currently includes 41 described species of which 40 are accommodated in the nominal subgenus, and one in the subgenus *Mylaconeus* Pesarini, 1970 (Borovec, 2013; Borovec & Perrin, 2016). The absolute majority of species are distributed in the warmer parts of the Mediterranean basin.

The most recent and comprehensive revision of this group was published by González (1970), who however confused members of this genus with those of *Desbrochersella* Reitter, 1906, a morphologically similar genus of Omiini Shuckard, 1840 (Alonso-Zarazaga & Lyal, 1999). Distinguishing features for the above mentioned genera were provided by Borovec & Perrin (2016), who also described new species, proposed new combinations and several new synonyms, outdating the recent catalogue of Borovec (2013).

Four species of *Chiloneus* were recorded from Italy, of which three belong to the nominotypical subgenus, and one to the endemic subgenus *Mylaconeus* (Abbazzi & Maggini, 2009; Borovec, 2013).

MATERIAL AND METHODS

In the last 10 years, regular visits to the Pelagie islands were carried out by one of us (AC), mostly to study the bird and dragonfly fauna (Corso, 2005; Corso et al., 2009, 2012). During October and November 2016, several specimens of *Chiloneus* were hand-collected on sea squill after heavy rains on Linosa island. A few weeks later, in view of the results obtained in Linosa, the same plant was successfully investigated on Lampedusa island in order to check the presence of *Chiloneus*. Given the faunistic and botanic similarity between the Pelagie and the Maltese archipelagoes (Corti et al., 2002), we decided to compare *Chiloneus* from the three islands, i.e. Linosa, Lampedusa and Malta, which are close to each other (Fig. 7). In Malta, one of us (DM) collected this weevil from the base of the same plant, called also sea onion or giant hyacinth, in a coastal garigue habitat in the south-eastern part of Malta (Munxar, l/o St. Thomas Bay), and additional material was available from Mellieha in Malta and Qbajjar in Gozo. Specimens are preserved in the personal collections of EC and RC in Rome, and of DM in Malta.

Body size of specimens is meant from an ideal line in front of eyes to the tip of elytra, excluding thus the rostrum, as usual for weevils. Measures were taken with an ocular grid.

Pictures were taken by Francesco Sacco with a Nikon 810 camera provided with a Mitutoyo Plan Apo 10X objective and a tube lens f 80mm 4X. Photo were then stacked with the program Helicon Focus 6.1, and further processed using the program Adobe Photoshop CS5.

Nomenclature of plants follows the checklist by Conti et al. (2005).

ABBREVIATIONS. AC: Andrea Corso; EC: Enzo Colonnelli; RC: Roberto Casalini; DM: David Mifsud. Distribution, AG: Algeria; BH: Bosnia and Hercegovina; CY: Cyprus; CR: Croatia; EG: Egypt; GR: Greece; KZ: Kazakistan; IT: Italy; JO: Jordan; IS: Israel; LB: Libya; MA: Malta; MO: Morocco; SP: Spain; TR: Turkey; TU: Tunisia.

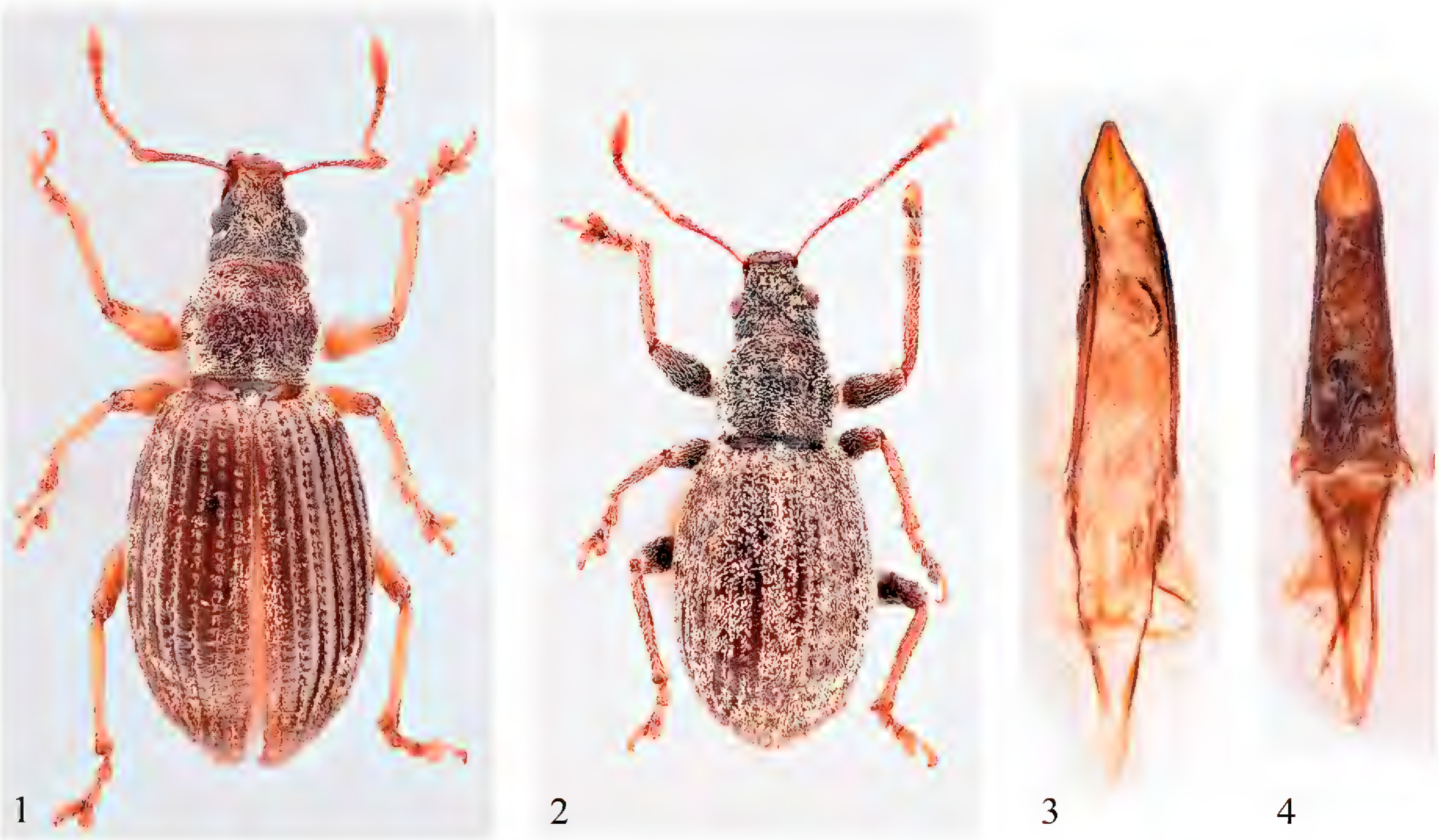
RESULTS AND DISCUSSION

On Linosa island, *Chiloneus solarii* Pesarini, 1970, a weevil previously known on the basis of the eight type specimens (Pesarini, 1970), was commonly found at the base of leaves of *Charybdis pancration* (Steinh.) Speta (Asparagaceae) (Fig. 5). It was found from sea level up to the top of Monte Vulcano (m 195 a.s.l.), feeding on leaves and producing irregular holes on their surface (Fig. 6). During the day, adults were hidden at the base of the rather succulent large leaves of the plant, being active at night. Similar behaviour was shown by *Chiloneus* on Lampedusa and the Maltese islands. Hundreds of exemplars were observed in Linosa, and about 130 were collected at Monte Vulcano, Monte Bandiera, Monte Rosso and Mannarazza. These are the first ecological observations for these insular *Chiloneus*, whose larvae probably develop inside the bulbs of *Charybdis* and/or possibly inside roots of the near plants.

During the five days spent on Lampedusa several *Charybdis* and similar plants from all over the island were investigated for the presence of this weevil. Interestingly, many specimens of *Chiloneus* were found all over the western part of the island, from Capo Ponente to Albero Sole, Punta dell'Acqua, Cala Pulcino and Cala Galera, whereas not a single specimen was found on the eastern part, east of the town of Lampedusa to Punta Sottile, Cala Francese and Capo Levante. In fact, on the eastern part of the island, and suggesting that the two weevils exclude each other from developing on the same plants, was rather common only the subendemic *Brachycerus schatzmayri* Zumpt, 1937. This rather common weevil produces similar damage to the leaves of the plant, and no less than 40 specimens were found. Apart this large Asparagaceae, no other plant was found as possible host of this huge *Brachycerus* Olivier, 1789 in the island. In the field it became evident that the specimens of *Chiloneus* from Lampedusa were sligthly different from those found in Linosa.

Specimens from Linosa and Lampedusa were morphologically compared, and it was found that they belong to two apparently different species. In fact, the specimens from Lampedusa were very similar to *Chiloneus hoffmanni* González, 1970, a species considered endemic to the Maltese archipelago (Mifsud & Colonnelli, 2010). From side to side examination of numerous specimens of *Chiloneus* from Malta and Lampedusa, we were able to identify the *Chiloneus* from Lampedusa as *C. hoffmanni*, a species never reported for the Italian fauna.

Given the close relationship of these insular *Chiloneus* to one another and their variability of size, density and colour of scales of integument, absence or presence and size of profemoral tooth, the only reliable feature which allows discrimination of *C. hoffmanni* (Fig. 1) from *C. solarii* (Fig.



Figures 1, 3. Male of *Chiloneus hoffmanni* from Lampedusa (Sicilian Channel, Italy), habitus and aedeagus from above, respectively. Figures 2, 4. Male of *Chiloneus solarii* from Linosa (Sicilian Channel, Italy), habitus and aedeagus from above, respectively. Photos by Francesco Sacco.

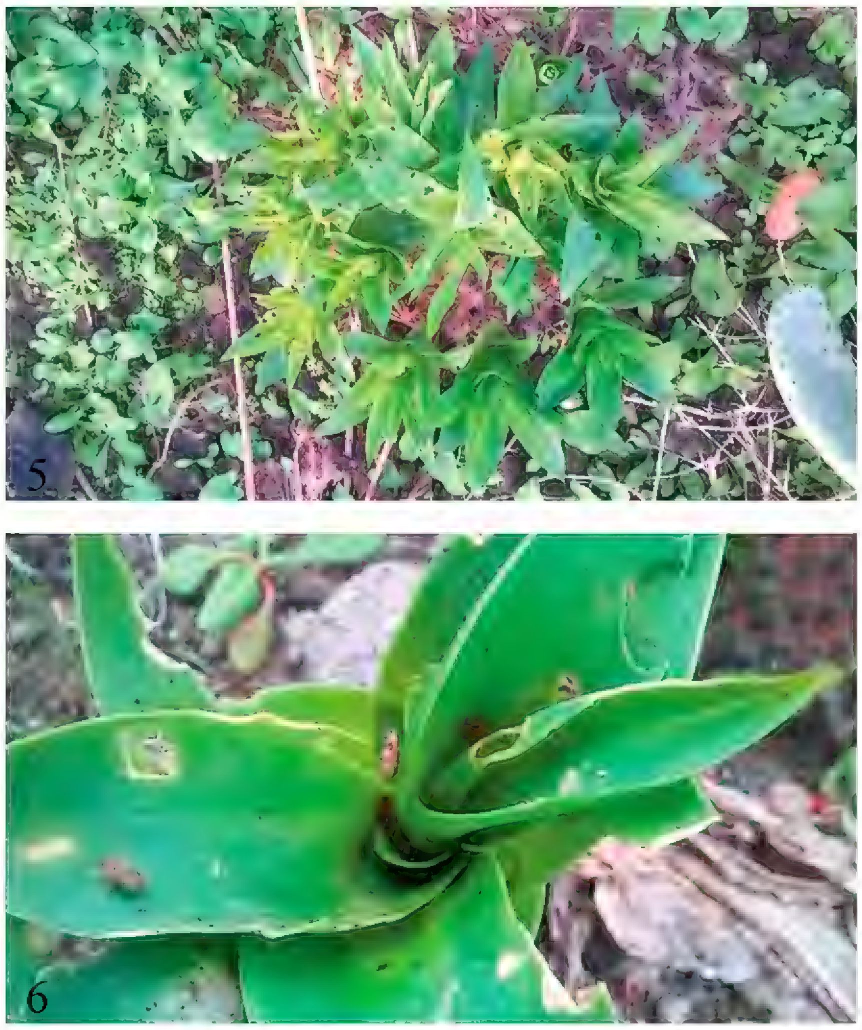


Figure 5. Leaves of *Charybdis pancration* cribbled by adults of *Chiloneus solarii* in Linosa (Sicilian Channel, Italy). Figure 6. Detail of the same, with some insects half-hidden inside the rosette of leaves. Photos by Andrea Corso.

2) are the striae of the latter which are clearly narrower since their punctures are at most as wide as 1/3 of the width of the flat dorsal intervals, whereas in *C. hoffmanni* at least some striae are formed by punctures as wide as half of the often quite convex intervals. The aedeagus and spermatheca are very similar in both species, merely the aedeagus of *C. hoffmanni* is slightly wider than that of *C. solarii* (Figs. 2 and 4). The body size of *C. hoffmanni* is also on average somewhat larger (mm 4.0–5.5, mean 4.6) than that of *C. solarii* (mm 3.5–5.0, mean 4.2). The presence or absence of minute blunt profemoral tooth cannot be used to differentiate these two species as indicated by Pesarini (1970), since a great variability was observed following examination of more than 220 specimens at hand.

In general, vestiture of *C. hoffmanni* is also sparser, and its integument more polished and paler, whereas the colour of scales varies in both species from golden-brownish to metallic greenish. We plan to carry out molecular studies next year to better assess the taxonomic status of these extremely close insular populations.

CHECKLIST

As already pointed out, the checklist of *Chiloneus* provided by Borovec (2013) became outdated after the publication of the work by Borovec & Perrin (2016) in which several taxonomical, nomenclatural and distributional changes were made. It seems thus appropriate to provide here under an updated list of all species of this genus, using a format slightly different from that used in the catalogue by Löbl & Smetana (2013). However, same country abbreviations are being used to facilitate comparison in distributional data. Indented names are synonyms. The list is presented here under.

Chiloneus (***Chiloneus***) Schoenherr, 1842

Chilonorrhinus Reitter, 1915
Microelytrodon Pic, 1945
Rhinochrosis Desbrochers des Loges, 1892

aliquoi (Pesarini, 1975) - IT
barbaricus (González, 1970) - AG
    vaulogeri (Desbrochers des Loges, 1897)
belloi Borovec et Weill, 2016 - SP
brevipilis Desbrochers des Loges, 1893 - AG, TU
    tuniseus Desbrochers des Loges, 1897
brevithorax Desbrochers des Loges, 1875 - CY
    theresae (Pic, 1945)
carinidorsum Desbrochers des Loges, 1871 - AG
chevrolati Tournier, 1874 - MO, PT, SP
    parvus (Stierlin, 1899)
    subglobatus (Desbrochers des Loges, 1892)
    tingitanus (González, 1970)
chobauti (Desbrochers des Loges, 1897) - AG MO, TU
    inhumeralis (Pic, 1903)
cinerascens (Rosenhauer, 1856) - AG, MO, SP
    nitens (Pic, 1904)
    seminitidus (Hustache, 1941)
corcyreus Penecke, 1935 - GR (Kerkyra)
corpulentus (Kiesenwetter, 1864) - GR
cyrenaicus Borovec et Weill, 2016 - LB
franzi (González, 1970) - SP
gabrieli Reitter, 1915 - GR
globulus Borovec et Perrin, 2016 - AG
hispidus (González, 1972) - JO

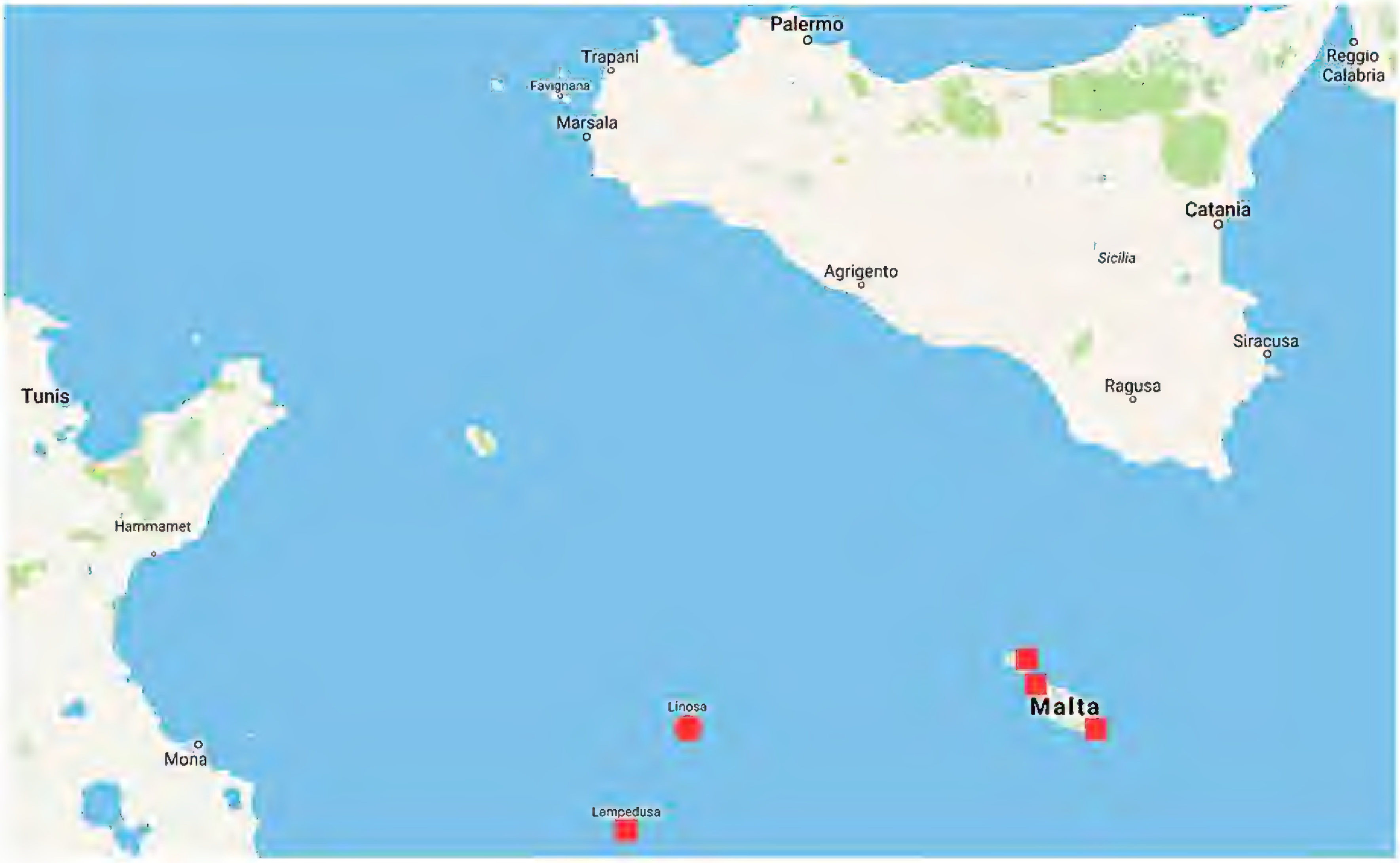


Figure 7. Map of central Mediterranean, showing the position of Linosa, Lampedusa, and Maltese islands. Localities of *Chiloneus hoffmanni* are marked by red squares, whereas those of *C. solarii* are marked by a red dot.

hoffmanni (González, 1970) - IT (Lampedusa), MA
  deluccai Pesarini, 1970
infuscatus (Chevrolat, 1861) - AG, TU
  algericus Desbrochers des Loges, 1871
innotatus (Pic, 1927) - CY
  insulanus (González, 1970)
jonicus Kraatz, 1859 - GR
maculatus (Hampe, 1870) - BH, CR
maroccanus (Hoffmann, 1954) - MO
mediterraneus (González, 1970) - SP
meridionalis (Boheman, 1840) - IT (Sicily)
  championi (González, 1970)
  siculus Boheman, 1842
*minutissimus (*Pic, 1904) - AG
  nitidipennis (Pic, 1927)
  subannulipes (Pic, 1917)
omiasformis Borovec et Weill, 2016 - SP
ottomanus Desbrochers des Loges, 1892 - TR
pallidus Bajtenov, 1974 - KZ
pennatus (Faust, 1885) - AG, SP
  dividuus (Pic, 1904)
  pruinosus (Desbrochers des Loges, 1896)
pertusicollis (Fairmaire, 1868) - AG, EG
  nasutus Desbrochers des Loges, 1897
  ruficornis (Allard, 1869)
  sphaeropterus (Allard, 1869)
sahlbergi Reitter, 1915 - IS
scythropoides Reitter, 1915 - CY
sitoniformis Reitter, 1915 - IS
sitonoides Reitter, 1915 - AG
solarii Pesarini, 1970 - IT (Linosa)
submaculatus (Pic, 1917) - AG, TU
  alboscutellaris (Pic, 1917)
syriacus (Stierlin, 1886) - IS
tenietensis Borovec et Perrin, 2016 - AG
vaulogeri (Pic, 1896) - LB, TU
  alluaudi (Pic, 1903)
  pilosulus Normand, 1953
veneriatus Normand, 1937: 244 - TU

***Chiloneus* (*Mylaconeus*)** Pesarini, 1970

lonai Pesarini, 1970 - IT

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MONOGRAPH

PROCEEDINGS OF THE 3rd INTERNATIONAL CONGRESS "BIODIVERSITY, MEDITERRANEAN, SOCIETY"

SEPTEMBER 4th-6th, 2015
NOTO-VENDICARI, ITALY

Juniperus turbinata Guss. - Piano Pirrera, Acate, Sicily

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***Juniperus turbinata* Guss. (Cupressaceae).** *Juniperus phoenicea* was described by Linnaeus (1753) from specimens collected from Montpellier, southern France; later Gussone (1845), described *J. turbinata* from southern Sicily differentiating it from the previous one. After many taxonomic vicissitudes, the two species are currently recognized by various authors and by the IUCN's Conifer Specialist Group. *Juniperus turbinata* differs from *J. phoenicea* mostly by having a larger (12-14 mm), sub-ovoid cone and leaves without scarious border (Arrigoni, 2012). *J. phoenicea* is a western European taxon that grows in a wide bioclimatic range from thermo- to supramediterranean belt with semiarid to humid ombrotype, in Spain, southern France, Italy in Maritime and Apuane Alps, while *J. turbinata* is found from the infra- to supramediterranean belt with arid to humid ombrotype and is widespread in the Mediterranean region and Canary Islands, both in coastal and inland regions (Mazur et al., 2016). *J. turbinata* is a large shrub or a small tree (8-12m tall), which grows mainly in coastal areas of the Mediterranean region and in mountains of northwest of Africa. In Sicily, the species is generally rare but a large population was recently discovered near Acate in SE Sicily (Minissale & Sciandrello, 2013). It is a typical Mediterranean species globally evaluated as Near Threatened (NT) by the IUCN world red list (Farjon, 2013). In fact although it is widely distributed along the coasts of the Mediterranean, subpopulations are scattered and usually small or very small. It often occurs close to urbanized coastal strips, or paleo-dunes where much of the original habitat has been destroyed. So reinforcement of *J. turbinata* populations and habitat restoration should be implemented.

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Pietro Minissale, Dipartimento di Scienze Biologiche, Geologiche e Scienze Ambientali, Università di Catania, Via A. Longo 19, 95125 Catania, Italy; e-mail: p.minissale@unict.it - Cover photo by Pietro Minissale

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MONOGRAPH

Introduction

Considerations on the International Congress "Biodiversity, Mediterranean, Society"

Giorgio Sabella

Department of Biological, Geological and Environmental Sciences - Section of Animal Biology "M. La Greca", University of Catania, Via Androne 81, 95124 Catania, Italy; e-mail: sabellag@unict.it

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Proceedings of the 3rd International Congress "Biodiversity, Mediterranean, Society", September 4th-6th 2015, Noto-Vendicari (Italy)

The Congress, held in September 2015 in Noto-Vendicari (Siracusa, Sicily, Italy) (Figs. 1, 2), the Sicilian town declared as World Heritage Site by UNESCO, represented a new opportunity for scientific debate (as in the previous meetings held in 2012 in Palermo and 2014 in Cefalù-Castelbuono, Sicily, Italy), among university researchers and scholars, members of scientific and environmentalist associations, operators involved in environmental management and territorial planning, managers of protected areas, scholars dealing in energy resources, communication and environmental education.

In particular, the conference focused on: i) plant and animal biodiversity; ii) biological and ecological research, included the anthropogenic impact, particularly in the Mediterranean, placing attention on protected areas and their role; iii) issues related to the debate concerning the sustainability and its perspectives in the field of energy, medicine, education and involvement of civil society.

A further aim of the congress was also to strengthen collaboration, international friendships and networks, already established in previous meetings, as well as to extend the debate on nature conservation to new areas, favoring the formation of a large cultural community who share a common interest in environmental sustainability starting from a vision of ethics and not a consumerist or opportunistic one.

These themes - the relationship between man and environment and of the development of a truly and not only nominal, sustainable lifestyle - are highly topical and have great importance not only for the conservation of nature, but especially for the survival of our Planet.

Over the past 25 years, globalization has resulted in rapid and profound changes in society, creating many new opportunities, but also generating problems in the implementation of development models and ensuring environmental sustainabilty.

It is clear that many environmental problems, such as, climate change, the equitable use of resources, mutual respect for the different cultures, conservation of migratory species and the control of the introduction of alien species, require the adoption of global policies and cannot be dealt on a national or local scale. However, this must not prevent anyone from adopting correct nature conservation policies on all levels, including those involving change in personal behaviors.

In this context, the study of biodiversity at all levels, genetic variability, species, communities and ecosystems, it is crucial to understanding the mech-

Figure 1. Noto Cathedral
(Sicily, Italy, photo P. Iuvara).

Figure 2. Vendicari, Salinaro House
(Sicily, Italy, photo P. Iuvara).

anisms that regulate the functioning of nature, set conservation policies and environmental management based on scientific criteria and not merely on aesthetical or worse yet utilitarian basis. On the other hand, it is increasingly evident that it is necessary to rethink the current models of society based on consumism and on uncontrolled exploitation of resources.

For this reason, the publication of the Proceedings of the Congress has been divided into two sections. The contributions of the first section, mainly bio-naturalistic and involving many and varied aspects of biodiversity of animal, vegetation and habitat, are published in the Biodiversity Journal, while the contributions of the second section, which examine the relationship between man and environment, will be published in the Proceedings and Memoirs of Ente Fauna Siciliana.

Biodiversity Journal, 2017, 8 (1): 49–58 **MONOGRAPH**

Modern taxonomic and biogeographic approaches to biodiversity in the Mediterranean area

Alessandro Minelli

Department of Biology, University of Padova, Via Ugo Bassi 58 B, I 35131 Padova, Italy; email: alessandro.minelli@unipd.it

ABSTRACT I review here examples of recent progress in the taxonomy and biogeography of Mediterranean taxa. Morphological approaches have still much to offer, as shown by a study of the Sicilian species of the wingless weevil genus *Pseudomeira* Stierlin, 1881 (Coleoptera Curculionidae). A systematic analysis of molecular markers, however, is revealing a huge number of previously unsuspected cryptic species, as in the scarab genus *Pachypus* Dejean, 1821 (Coleoptera Pachypodidae). Other molecular studies have revealed very deep phylogeographic structure in the Corsican brook salamander; the presence of six or more species hitherto lumped under *Rumina decollata* (Linnaeus, 1758) (Pulmonata Subulinidae), in a snail genus in which biparental and uniparental reproduction coexist; the conservation of the same male pheromone in vicariant species of the scarab beetles of the genus *Osmoderma* Lepeletier et Serville, 1828 (Coleoptera Cetoniidae); the interplay of vicariance and dispersal events in giving rise to the different taxa of the land snail genus *Chilostoma* Fitzinger, 1833 (Gastropoda Helicidae) inhabiting the Greek islands. Further examples of modern biogeographic studies are a morphometric analysis revealing the preferential localization of steep slopes of phenetic diversity of seven butterfly species groups in the Tuscan archipelago and across the Strait of Messina; a research on tenebrionid beetles showing that present distribution patterns are not completely explained by postglacial recolonization from Pleistocenic refugia; a comparative analysis of the diversity of patterns (explained in part by vicariance, in part by dispersal) in the biota on the two shores of the Strait of Gibraltar. A study on the ocellated lizards provides a nice analysis of climatic niche evolution throughout speciation. Finally, a comparative study of mtDNA from spurge hawkmoths collected between 1884 and 1986 has demonstrated the complete disappearance, within one century, of a lineage from a former area of sympatry with what now appears as its vicariant.

KEY WORDS dispersal; ecological niche; molecular taxonomy; taxonomic methods; vicariance.

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INTRODUCTION

The terrestrial and freshwater biota of the Mediterranean area have long attracted the attention of zoologists and botanists. Their study has always been a challenging but eventually rewarding task for the taxonomist confronted with a sometimes explosive fragmentation of isolated populations whose taxonomic rank, either specific or subspecific, continues to trouble us to date, as well as for the biogeographer looking for an interpretation of present-day distributions in the light of past events, including palaeoclimatic history.

There is plenty of lineages within which ongoing speciation is worth investigation. But there are also persisting traces of palaeogeographic and palaeoecological events, suggesting for example areas of glacial refugium and routes of (re)colonization. There are distribution patterns that would support a vicariance paradigm in biogeography alongside others supporting dispersal instead.

In the last few decades, the study of the Mediterranean biota has been often addressed by means of new research tools, especially those of molecular systematics, but also other approaches, for example those of multivariate morphometrics, have contributed and are still contributing to an evolving appreciation of biodiversity in the Mediterranean area.

In the following, I will review a few recent studies, beginning with examples of accurate evaluation of species diversity in critically difficult genera, due to the careful application of different taxonomic approaches, either morphological or molecular. Next, I will move into the spatial dimension of biological diversity, thus giving examples of studies addressing the dispersal vs. vicariance dichotomy, the localization of refugia or the subtle interpopulation relationships revealed by phylogeography. I will provide examples focussing on the evolution of Mediterranean biota in geological times as well as others revealing instead dynamic changes in very recent time, virtually in the present.

MORPHOLOGY TO MOLECULES

Since the advent of molecular systematics and especially since the development of cheap and highly efficient sequencing techniques, many authors have expressed critical or at least sceptical attitudes in respect to the usefulness of purely morphological analyses in taxonomy, and especially in the reconstruction of phylogeny. This criticism is arguably justified in some groups, but it is simply wrong as a general rule. Specialists generally know where to look for reliable taxonomic traits, they also know that their study may require operationally challenging and time-consuming work. Coleopterists, for example, know well that the aedeagus (the main component of the male copulatory organ) is generally diagnostic at the species level, even in groups with very uniform external morphology; in some groups, additional information (occasionally even more diagnostic than the morphology of the aedeagus) can be found in the female reproductive apparatus, especially in the sclerotized spermatheca. A very good example of taxonomic study based on a careful study of genital structures is Bellò & Baviera's (2011) revision of the Sicilian species of *Pseudomeira* Stierlin, 1881 (Coleoptera Curculionidae), a genus of wingless weevils whose members are nearly undistinguishable on external morphology, but are confidently set apart by examining the last two abdominal tergites, plus aedeagus, tegmen and spiculum gastrale of males, and ovipositor, spiculum ventrale and spermatheca of females. The importance of using female characters is exemplarily demonstrated by this study because, of the 18 Sicilian species now recognized in the genus, six are parthenogenetic and thus represented by females only.

An obvious superiority of many taxonomic studies based on morphology in respect to most of those based on molecules is the much better sampling, both in terms of localities and as number of specimens. For example, Bellò & Baviera (2011) examined over 2000 specimens from 116 localities, a sampling that allowed them to find a number of species new to science.

It must be acknowledged, anyway, that because of the rapidly increasing efficiency and the also rapidly decreasing cost of DNA sequencing, molecular studies are also increasingly based on extensive sampling. Results are often puzzling and sometimes astonishing. A case in point is the current progress with the taxonomy of the scarab genus *Pachypus* Dejean, 1821 (Coleoptera Pachypodidae), insects of extremely reduced vagility, due in particular to the wingless condition of the females. To the first-described species, *P. candidae* (Petagna, 1787), recorded from Southern Italy, Latium, Elba, Sardinia, Corsica, old taxonomists were able to add only *P. caesus* Erichson, 1840, from Sicily, and *P. demoflysi* Normand, 1936, only known from Cap Serrat in Tunisia and Annaba in Algeria. The picture, however, has changed rapidly since Sparacio (2008) recognized the Sardinian representatives of this genus as belonging to a new species, *P. melonii* Sparacio, 2008. In Sardinia, however, another, morphologically quite different species was described soon thereafter, *P. sardiniensis* Guerlach, Bazzato et Cillo, 2013 (Guerlach et al., 2013). It was not difficult then to suspect that the overall taxonomic articulation of the *Pachypus* populations in the Tyrrhenian area is possibly more complex than accepted thus far. The study of two markers (Cox1 and 16S) of the mitochondrial DNA of an extended sample from many localities of Italiy and Sardinia (Ahrens et al., 2015) has revealed indeed a huge genetic diversity, suggesting the presence of up to 42 species!

PHYLOGEOGRAPHY

With their study of the Corsican brook salamander, *Euproctus montanus* (Savi, 1838), Bisconti et al. (2013) have provided a fine example of the complex phylogeographic patterns that may exist among the populations of what has been hitherto regarded as a quite uniform insular endemic. In the case of a poorly vagile animal, an island of the size of Corsica can host indeed a lot of ancient and geographically structured variation. The most surprising result of this study is the strongly unequal distribution of recognizable lineages of *Euproctus* Gené, 1838 in the different parts of the island. The authors found five main clades, all but one restricted to northern Corsica and essentially allopatric: only in one sample did they find sympatric specimens belonging to two different lineages.

Besides the strictly scientific interest of these findings, this detailed phylogeographic analysis has important consequences in terms of conservation, because it has revealed a previously unsuspected concentration of intraspecific diversity in a restricted part of the island, contrasting with the uniform presence of one lineage only throughout most of Corsica. Critically important in terms of conservation is the fact that the four localized lineages have each been sampled in one or two localities only. Northern Corsica has been also identified as the theatre of ancient phylogeographic splittings between lineages of other organisms with limited dispersal power, such as the land snail *Solatopupa guidoni* (Caziot, 1903) (Ketmaier et al., 2010), the isopod *Helleria brevicornis* Ebner, 1868 (Gentile et al., 2010) and the rockrose *Cistus creticus* Sibth. et Sm. (Falchi et al., 2009).

Remarkable is the amount of divergence among the five *Euproctus montanus* lineages, which is quite larger than the genetic differences found among species pairs in several lineages of European newts, for example between *Calotriton asper* (Dugès, 1852) and *C. arnoldii* Carranza et Amat, 2005 (Carranza & Amat, 2005), *Triturus marmoratus* (Latreille, 1800) and *T. pygmaeus* (Wolterstorff, 1905) (Carranza & Amat, 2005), or *T. carnifex* (Laurenti, 1768) and *T. macedonicus* (Karaman, 1922) (Arntzen et al., 2007).

The splits between these *Euproctus* lineages have been dated 2.6–5.8 Myr, in agreement with the divergence time estimated for other parallel splits involving different taxa previously studied in Corsica: these include a lizard (*Archaeolacerta bedriagae* (Camerano, 1885)) with parapatric lineages living in northern Corsica that split apart 3.7–5.9 Myr ago (Salvi et al., 2010).

Bisconti et al.'s (2013) results deserve two additional comments. The first is of methodological nature. The clear phylogeographic pattern they discovered among the populations of *Euproctus montanus* is based on comparisons of mitochondrial DNA markers, but no parallel pattern was recovered based on nuclear DNA markers. This is certainly not a reason to regard their result with suspicion, but it is a warning that the whole story has not been reconstructed yet in full. The second point, amply discussed by the authors themselves, is that the geographical isolation between the *Euproctus* clades cannot be explained in terms of either present or ancient geographical barriers; however, the palaeoclimatic history of the island may have been largely responsible for the geographic pattern of distribution of the mountain newt lineages, in the light of Suc's (1984) reconstruction, based palynologic and macroflora analyses, according to which the palaeoenvironmental evolution of north-western Mediterranean was characterized during the Pliocene and Early Pleistocene by a progressive decrease in moisture, with dry summers, favouring forest clearing, becoming a regular feature approximately 3.2 Myr ago.

SPECIES IN FACULTATIVELY UNIPARENTAL ORGANISMS

Delimiting species is often very critical when taxonomic units do not coincide with close reproductive communities, that is, in the presence of hybridization, but also when reproductive communities do not exist at all, that is, in the case of organisms with uniparental reproduction. Under these circumstances, it is pretty impossible to adopt uniform procedures: every case is to some extent different from the others. Particularly challenging are the plants and animals adopting a mixed reproductive strategy, that is those in which biparental and uniparental reproduction coexist. A Mediterranean example is *Rumina* Risso, 1826 (Pulmonata Subulinidae), a genus of facultatively selfing (self-fertilizing) snails. Based on morphology, three species have been traditionally recognized. A polymorphism of body colour is also long known among the populations hitherto referred to *R. decollata* (Linnaeus, 1758). A recent study by Prévot et al. (2013) has addressed the question of whether this diversity corresponds to fixed alternative phenotypes due to sustained selfing or to diverging taxonomic units. Nuclear and mitochondrial DNA sequences were compared, revealing an unexpected phylogenetic structure suggesting the presence of 7–10 species, one corresponding to *R. saharica* Pallary, 1901 and the others currently grouped under the name *R. decollata* (Linnaeus, 1758). The contribution of the facultative selfing reproductive strategy to the ongoing differentiation within this snail genus remains, however, obscure.

MORPHOLOGY, DNA AND PHEROMONES

Before the advent of methods for sequencing proteins and nucleic acids, taxonomists had learned to extend comparisons beyond morphology, to include data on the presence or absence of specific molecules of modest size. Particularly attractive were sexual pheromones, because these are often a (the) key cue through which the animal assesses the identity of a potential partner. Nowadays it is possible to combine data on pheromones (or on the response to pheromones) with those obtained from morphology and standard molecular investigations, as in the recent study of Zauli et al. (2016) on the scarab beetles of the genus *Osmoderma* Lepeletier & Serville, 1828 (Coleoptera Cetoniidae). The taxonomy of these rare (and protected) insects is difficult. Traditionally, only a single species *O. eremita* (Scopoli, 1763) was recognized in our area, but other taxa were quite recently proposed, based on slight morphological differences in agreement with a consistent geographic pattern. From a first molecular study (Audisio et al., 2009), based on the mtDNA cytochrome C oxidase I gene (COI), it resulted that at least four species should be recognized: the western *O. eremita*, the Sicilian endemic *O. cristinae* Sparacio, 1994 and two eastern species, *O. barnabita* Motschulsky, 1845 and *O. lassallei* Baraud et Tauzin, 1991; a fifth species, *O. italicum* Sparacio, 2000, occurs in S-Italy (see Audisio et al., 2007). A new study by Zauli et al. (2016) has confirmed the differentiation of *O. eremita* and *O. cristinae* at the level of species, supported now by more extensive molecular evidence (AFLP, i.e. amplified fragment length polymorphism markers, in addition to COI) and by a morphometric analysis of male genitalia. The study of pheromones, however, has failed to identify any difference between the two species: the males of both taxa produce and release (R)-(+)-c-decalactone, whose attractive power has been demonstrated in either case in the field. According to the authors, the allopatry between *O. eremita* and *O. eremita* can explain the use the same sexual pheromone by both species, due to the lack of selective pressure for the evolution of a prezygotic isolation mechanism.

DISPERSAL VS. VICARIANCE

A research on the Greek representatives of the land snail genus *Chilostoma* Fitzinger, 1833 (Gastropoda Helicidae) (Psonis et al., 2015) revealed a complex biogeographic history of these molluscs, involving both vicariance and dispersal patterns.

These snails are highly diversified and present high levels of endemism. In this study, the authors investigated the phylogenetic relationships of the lineages of the genus *Chilostoma* distributed in Greece based on partial DNA sequences of two mitochondrial DNA (16S rRNA and COI) genes. Complete sequences of one nuclear gene (ITS1) representing the major mitochondrial lineages were also analyzed. The phylogenetic trees revealed three distinct major clades, corresponding to the three subgenera *Cattania* Brusina, 1904, *Josephinella* Haas, 1936 and *Thiessea* Kobelt, 1904, which separated in the late Miocene. They started differentiating into distinct species during the Pliocene and

Pleistocene through not less than nine vicariance and seven dispersal events.

STEEP SLOPES OF PHENETIC DIVERSITY

Even in the case of species with very large distribution areas, the straits between islands or continental masses are the places where morphology changes more significantly between populations living even at a modest distance. By using a diversity of morphometrics methods, Dapporto et al. (2012) estimated this relationship between morphological differentiation and geographic proximity in terms of phenetic slope, a measure whose scores can be plotted onto a map, providing impressive and easily graspable results. Their study targeted the Western Mediterranean populations of seven butterfly species groups, including samples from Sardinia, Sicily, Corsica, the Balearic Islands and several smaller islands of the circum-Italian, circum-Sicilian and circum-Sardo-Corsican archipelagos. Geometric morphometrics was applied to the male genitalia. Here are the main results:

Lasiommata megera (Linnaeus, 1767) group - two distinct morphotypes, one (*L. paramegaera* (Hübner, [1824]) in Sardinia, Corsica, Capraia and Montecristo, the other (*L. megera*) in the remaining islands studied, Europe and North Africa. Italian populations possibly representing a third morphotype.

Pyronia cecilia (Vallantin, 1894) - two distinct morphotypes, one on most West Mediterranean islands and in Spain, the other in Italy; intermediate populations in North Africa and Sicily.

Pyronia tithonus (Linnaeus, 1767) - a highly divergent population in North Africa and a south-west to north-east cline; similarity between populations on Sardinia, Corsica and Elba with those in south-eastern France and between populations from Spain and the Balkans.

Maniola jurtina (Linnaeus, 1758) - two morphotypes, one in North Africa, Spain, Sicily, Sardinia and the surrounding islands, the other in Italy and Eastern Europe; intermediate populations in Corsica, Elba, Giglio, Pianosa, Capri, Ischia.

Coenonympha pamphilus (Linnaeus, 1758) group - two closely related species: *C. lyllus* (Esper, 1805) in North Africa, southern Spain, the Balearics, Sardinia and Sicily, *C. pamphilus* in Corsica, the Italian mainland and neighbouring islands as well as Eastern Europe; intermediate populations in France and Catalonia.

Hipparchia semele (Linnaeus, 1758) group - the nominal species in the European mainland; vicariant species on some islands (Ponza: *H. sbordonii* Kudrna, 1984; Aeolian Islands: *H. leighebi* Kudrna, 1976). The closely related *H. aristaeus* (Bonelli, 1826) group occurs in Sardinia, Corsica and the Tuscan islands (*H. aristaeus*) and North Africa (the vicariant *H. algirica* (Oberthür, 1876)). In Sicily the two groups occur in sympatry, with *H. semele* and a taxon, *H. blachieri* (Frühstorfer 1908), of the *H. aristaeus* group. This group is represented in southern Italy by *H. neapolitana* Stauder, 1921, together with populations of the *H. semele* group and individuals with intermediate characteristics suggesting hybridization between the two lineages.

In each species (or group of strictly related, vicariant species) the morphometric analysis of the shape of genitalia reveals narrow areas of steep variation. In most cases these areas correspond to sea straits; here are examples:

P. aegeria - a steep slope around Ponza and along the Tyrrhenian Sea; minor slopes between Ischia, Capri and the mainland, at the strait of Messina and in a few mainland areas.

Lasiommata megera/paramegaera - a steep slope in the Tuscan Archipelago where the two morphotypes come into close contact without any evidence of hybridization.

Pyronia cecilia - major slopes between the Tuscan Archipelago and the Italian mainland.

Pyronia tithonus - a steep slope between the Tuscan islands and Italian mainland, between France and Italy and between Morocco and Spain but also alongside Corsica.

M. jurtina, steep slopes correspond to all sea straits between the Italian Peninsula and neighbouring islands (Elba, Giglio, Ischia, Capri, Sicily).

Summing up, this study confirms the distinctness between the insular Mediterranean populations and those of the mainland, a result to some extent surprising in a group of insects with good flying power (see also Cesaroni et al., 1994; Dapporto et al., 2009, 2011; Dapporto, 2010). As a general trend, the butterfly populations of Mediterranean islands are more similar to those of more western and southern areas. For example, those of Sardinia are very similar to those living in North Africa. To explain this trend, Dapporto et al. (2012) suggested two hypotheses. The first of these is based on the possible passive transport by winds, which mainly blow in summer from the west, however, this might explain the similarity between the fauna of Spain and Sardinia, but not between Tunisia and Sardinia. Therefore, the authors favour an alternative hypothesis based on palaeogeography and palaeoclimatology.

QUATERNARY REFUGIA

During most of the Quaternary, the environmental conditions oscillating between peaks of cold (glacial) and temperate (interglacial) climate caused the extinction of many species and the migration of others. The complex orography of the continent put strong constraints on those migratory routes, the paths of which can be reconstructed quite accurately. During the glacial peaks, a number of species survived in southern refugia, from which they eventually moved back towards higher latitudes in the inter- or postglacial times. An excellent summary of our knowledge of these events is Hewitt (1999).

Of recent studies focussing on the reconstruction of postglacial colonization trajectories in the Mediterranean area, I will single out Fattorini & Ulrich's (2012) research on tenebrionid beetles.

According to their reconstruction, tenebrionid beetles recolonized Europe, in post-glacial times, following multiple trajectories, moving from two refugial centres, one in the Iberian peninsula, the other in the Balkan peninsula. As expected, the lineages involved in the postglacial recolonization were the more tolerant and, possibly, more mobile species, whereas many species with low dispersal capabilities that evolved in those southern refugia could not spread northwards.

These results are broadly in accordance with the long established patterns of recolonization from a number of glacial refugia in southern Europe (e.g., Taberlet et al., 1998; Dapporto et al., 2009, 2011; Dapporto, 2010), but also revealed that the whole biogeographic history of Europe throughout the Holocene and late Pleistocene cannot be reduced to that. Fattorini & Ulrich (2012) interpret the high levels of endemism of tenebrionids in Spain and Sardinia as witnessing that the faunas of these regions originated during the Tertiary period and have remained substantially isolated since then. This indicates a complex history involving geographical isolation and past and current conditions. In other terms, besides the effects of the last Pleistocene glaciation that largely erased the effects of previous palaeogeographic and palaeoecological events, some pre-Pleistocene patterns are still evident in the distribution of European tenebrionids. This is suggested for example by phylogenetic reconstructions of the Mediterranean species of *Tentyria* Latreille, 1802 (Palmer & Cambefort, 2000) and *Blaps* Fabricius, 1775 (Condamine et al., 2011), indicating an ancient colonization of southern European areas from North Africa across the Gibraltar Strait.

BIOVIVERSITY ACROSS THE STRAIT

If the Mediterranean basin as a whole is long acknowledged as a hotspot of biological diversity, less attention is generally paid to the local concentration of biodiversity in smaller, sometimes very strictly localized areas. In a very informative review paper, Rodríguez-Sánchez et al. (2008) focussed on the floristic diversity of two shores of the Strait of Gibraltar, itself a pivotal area between two larger biodiversity hotspots as the southern part of the Iberian Peninsula and NW Africa. This small region hosts a relict flora with a high percentage of endemic species, and the dominance of vegetation types other than the usual Mediterranean-type sclerophyllous forests and shrublands.

The authors show that plant endemism in the area of the Strait of Gibraltar is associated with poor soils and mild Mediterranean climate, whereas relictness is primarily associated with riparian and humid habitats, probably stable to some degree since the Late Tertiary.

The phylogeographic studies performed thus far on a number of animals have shown that the degree of isolation correlated to the presence of the Strait of Gibraltar is very different from case to case. Although narrow, this strait separates distinguishable lineages in a nearly sedentary bird such as the great bustard *Otis tarda* Linnaeus, 1758 (Broderick et al., 2003). However, other animals with low dispersal power have been apparently able to cros the Strait during the last 60 000 years, in some cases at least with the help of humans; there are examples among mammals (the white-toothed shrews of the genus *Crocidura*

Wagler, 1832; Cosson et al., 2005) and snakes (the false smooth snakes of the genus *Macroprotodon* Guichenot, 1850; Carranza et al., 2004) and even in the salamanders of the genus *Pleurodeles* Michahelles, 1830 (Veith et al., 2004). A different story is told by the lizard *Psammodromus algirus* (Linnaeus, 1758), which crossed the Strait around 2 million years ago, despite its poor attitude to long-distance dispersal (Carranza et al., 2006). Unable to cross the Strait were other vertebrates, currently represented by different, vicariant species on the European and African shores: for example, the spadefoot toads are represented by *Pelobates cultripes* (Cuvier, 1829) in Iberian Peninsula, by *P. varaldii* Pasteur et Bons, 1959 in northern Africa (García-Paris et al., 2003). By vicariant taxa are also represented, on the European vs. African side of the Strait, the painted frogs of the genus *Discoglossus* Otth, 1837 (Fromhage et al., 2004) and the freshwater fishes of the genus *Barbus* Cuvier et Cloquet, 1816 (Zardoya & Doadrio, 1999).

CLIMATIC NICHE EVOLUTION THROUGHOUT SPECIATION

Ahmadzadeh et al. (2016) used the large ocellated lizards of the genus *Timon* Tschudi, 1836 to study the evolution of ecological niches through comparative phyloclimatic analysis and to determine the possible role of climatic niche evolution during the speciation process.

The authors established first a phylogeny of this taxon, based on three mitochondrial and two nuclear genes, and provided an age estimate for all lineage splittings leading to the six living species.

The large ocellated lizards are estimatd to have diverged from the sister genus *Lacerta* Linnaeus, 1758 ca. 18.6 Myr ago. Within *Timon*, two main clades diverged 14.5 Myr ago and today have widely disjunct distributions. The eastern clade includes the two oriental species *T. princeps* (Blanford, 1874) and *T. kurdistanicus* Suchow, 1936, which split apart 7.9 Myr ago. The western clade consists of the European subclade with the species *T. lepidus* (Daudin, 1802) and *T. nevadensis* (Buchholz, 1963), and the African subclade with the species *T. pater* (Lataste, 1880) and *T. tangitanus* (Boulenger, 1889). These two subclades are estimated to have split apart 7.4 Myr ago, while species divergence inside the European and African subclades has been dated 5.7 Myr and 6.0 Myr respectively.

The phylogenetic analysis suggests that the divergence between the eastern and western groups of *Timon* was determined by multiple vicariance events. As remarked by the authors, the same biogeographical patterns involving divergence and vicariance between a western and a eastern Mediterranean lineages has been found in other genera of reptiles and amphibians: among the reptiles, in the amphisbaenian genus *Blanus* Wagler, 1830 (the western *B. cinereus* (Bedriaga, 1884), *B. mettetali* Bons, 1963, *B. mariae* Albert et Fernández, 2009 and *B. tingitanus* Busack, 1988 vs. the eastern *B. strauchi* (Bedriaga, 1884)) (Vasconcelos et al., 2006; Albert et al., 2007; Sindaco et al., 2014); among the amphibians, in *Pelobates* Wagler, 1830 (the western *P. cultripes* (Cuvier, 1829) and *P. varaldii* Pasteur et Bons, 1959 vs. the eastern *P. syriacus* Boettger, 1889) (Tarkhnishvili & Gokhelashvili, 1999; Crottini et al., 2010) and *Pelodytes* Bonaparte, 1838 (the western *P. punctatus* (Daudin, 1802) and *P. ibericus* Sánchez-Herraíz, Barbadillo-Escrivá, Machordom and Sanchíz, 2000 vs. the eastern *P. caucasicus* Boulenger, 1896) (Van de Vliet et al., 2012).

In the following steps of their study, Ahmadzadeh et al. (2016) used multivariate statistics on species distribution models to characterize all species in terms of their ecological niches. The authors used the latter term in the sense of the so-called Grinnellian niche (cf. Grinnell, 1917), defined by Soberón (2007) as a "*subset* [..] *of scenopoetic variable space* [average temperature, precipitation, solar radiation, terrain aspect, etc.] *corresponding to geographic areas defined by actual or potential properties of [a] species*", rather than as Eltonian niche (cf. Elton, 1927; MacArthur, 1968), measured instead in terms of biotic interactions and resource-consumer dynamics (bionomic variables).

Niche divergence among species was quantified by Ahmadzadeh et al. (2016) by computing multivariate niche overlaps via two-dimensional and n-dimensional approaches. A generally low niche divergence emerged among the members of the eastern group, contrasting with the remarkable climatic divergence observed within the western group. The results suggest an important role of temperature seasonality in a Mediterranean and Atlantic climate context and a substantatial degree of niche conservatism in terms of microhabitats as described by vegetation cover.

POPULATION CHANGES DURING THE LAST CENTURY

Against the background of studies such as the example of *Euproctus montanus* discussed above, revealing a phylogeographic structure essentially frozen for a few million years, it is sensible to close with an example of the unexpectedly rapid pace at which the geographical distribution of different haplotypes can change in vagile organisms as are the hawkmoths (Sphingidae). The study of Mende & Hundsdoerfer (2013) on *Hyles euphorbiae* (Linnaeus, 1758) is also an excellent example of the precious information we can obtain from molecular studies of museum specimens.

Six distinct mitochondrial lineages are recognized in the Mediterranean region for this group of large moths. The mitochondrial lineage found throughout most of Europe (*H. euphorbiae*) is also present on Malta, but is replaced by a different lineage (informally known as '*H. italica*') in Southern Italy and Sicily. By analyzing DNA sequences obtained from museum specimens collected at different times between 1884 and 1986, Mende and Hundsdoerfer (2013) provided a reconstruction of the evolution throughout the Twentieth Century of the mitochondrial demographic structure of the *Hyles euphorbiae* complex in Italy and Malta.

At the beginning of the XX century, the European (*H. euphorbiae*) lineage coexisted with the southern ('*H. italica*') one both in Southern Italy and in Sicily. The frequency of the latter lineage, however, went on increasing; if ca. 120 years ago it was slightly more abundant there than the *H. euphorbiae* lineage, its frequency increased till eventual fiaxtion in recent years. The current areal disjunction between *H. euphorbiae* and '*H. italica*' is thus a very recent pattern, tentatively explained by the authors as due to genetic drift following anthropogenic habitat loss and fragmentation, perhaps in combination with an impact from recent climate warming that may have favoured the spreading of '*H. italica*' populations.

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MONOGRAPH

Identification of emission sources from data of $PM_{2.5}$ chemical speciation measured with automatic monitors: application in a coastal site of the Mediterranean basin

Ettore Petralia*, Massimo Berico, Teresa La Torretta, Antonella Malaguti, Milena Stracquadanio & Chiara Telloli

ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development; SSPT-MET-INAT Atmospheric Pollution Laboratory. Centro Ricerche "E. Clementel", via Martiri di Monte Sole 4 , 40129 Bologna, Italy
*Corresponding author, e-mail: ettore.petralia@enea.it

ABSTRACT High-time resolution (1 hour) measurements of 11 species (organic carbon, elemental carbon, chloride, nitrite, nitrate, sulfate, sodium, ammonium, potassium, magnesium, calcium) within the $PM_{2.5}$ were conducted, from 3rd May to 30th June 2010, in a coastal site of Basilicata (Italy). Acquired data were analysed through Positive Matrix Factorization (PMF) method in order to individuate potential emission sources. This source apportionment evaluation revealed 5 factors separated as Vehicular traffic, Combustion of biomass, Secondary aerosol, Aged marine, Marine fresh and Dust. For each factor were defined profile, temporal trend, 24h-cycle and percentage contribution to measured $PM_{2.5}$, also emphasizing the relationship between factors and different wind conditions.

KEY WORDS Automatic monitors; High-time resolution $PM_{2.5}$ measures; Positive Matrix Factorization; Rural background site; Source apportionment.

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INTRODUCTION

The study presented here had as its overall objective the identification of emission sources (source apportionment) from $PM_{2.5}$ chemical speciation data collected by automatic monitors, and was conducted at a coastal site within the Mediterranean basin. In particular, attention was focused on the use of non-conventional measuring systems such as automatic monitor, in an intensive monitoring campaign with acquisition of high-time resolution data; it was verified the application of multivariate statistical methods to such resolution data typology (likely high variability), in order to detect and identify potential emission sources by a source apportionment receptor model approach for a rural background site where the sources are not particularly evident; finally, it was attempted to solve the emissive framework using a limited number of $PM_{2.5}$ chemical parameters, as described below.

MATERIAL AND METHODS

The study site, localised at the ENEA - Trisaia Research Centre (Rotondella, Matera), is a coastal area in Basilicata (Italy), 4 km away from the sea (Gulf of Taranto) and about 10 km distant from Appennino Calabro-Lucano (Fig. 1). In relation to the potential emission sources it is considered as rural background (according to the criteria in Italian Decr. Leg. 13 agosto 2010, n. 155) where the main activities in the area are agriculture and handicraft, thus missing important punctual emission sources. The distance from the nearest town of great extent (Taranto) is 60 km, while the distances from the nearest towns of medium size are 4 km (Nova Siri Scalo) and 6 km (Policoro). The distance from the main roads is around 600–700 meters, with the presence of a four lane motorway (SS106-Jonica) and a two lane motorway (SS653-Sinnica).

The weather framework regarding the wind for the entire sample period shows a prevalent direction along the NW-SE axis, where to phenomena of local breeze were alternating continuative perturbation events from NW; in fact more in detail were differentiated three wind condition periods: in addition to the local breeze situation, emerged situations of continuous perturbation from NW, and situations of local breeze associated with sand transport.

Instrumental set-up was consisting in a transportable container-laboratory hosting inside an URG 9000D Ambient Ion Monitor associated with two ion chromatographs to analyse the major soluble inorganic ions (Cl^-, NO_2^-, NO_3^-, SO_4^{--}, Na^+, NH_4^+, K^+, Mg^{++}, Ca^{++}), an SUNSET semi-continuous EC/OC analyzer for organic carbon (OC) and elemental carbon (EC), a control unit for the acquisition of weather data.

Other than the facility to work standing-alone via remote control, additional important advantages of automated sampling and measurement systems are the reduction or absence of positive and negative artefacts in the sample (due to the non-manipulation of specimen, the presence of denuder that allows the separation of the gas phase and of the aerosol phase, and the minimum sampling interval) and a low limit of detection value, with possibility to reveal even very low mass concentrations. Finally these tools allow to perform measurement campaigns for limited periods with anyhow a consistent number of data available, sufficient for advanced statistical analysis such as multivariate techniques through which is possible the identification and quantification of the emission sources. On the other hand the high-time resolution of data from automated monitors permits to obtain further information on the emission sources' activity, for example any possible variation within the daily cycle.

The sampling periods accounted for 59 days, from 3rd May to 30th June 2010, with an 1 hour-time resolution of measures; 11 species (organic carbon, OC; elemental carbon, EC; chloride, Cl^-; nitrite, NO_2^-; nitrate, NO_3^-; sulfate, SO_4^{--}; sodium, Na+; ammonium, NH_4^+; potassium, K^+; magnesium, Mg^{++}; calcium, Ca^{++}) within the $PM_{2.5}$ (aero-suspended particles < 2.5μm of diameter) were measured.

Factorial analysis with PMF (Positive Matrix Factorization) was applied at the concentration data; PMF allows to obtain information on the contribution of emission sources in a specific receptor site without knowing the sources' emissivity reference profiles. The solution to the factorial model

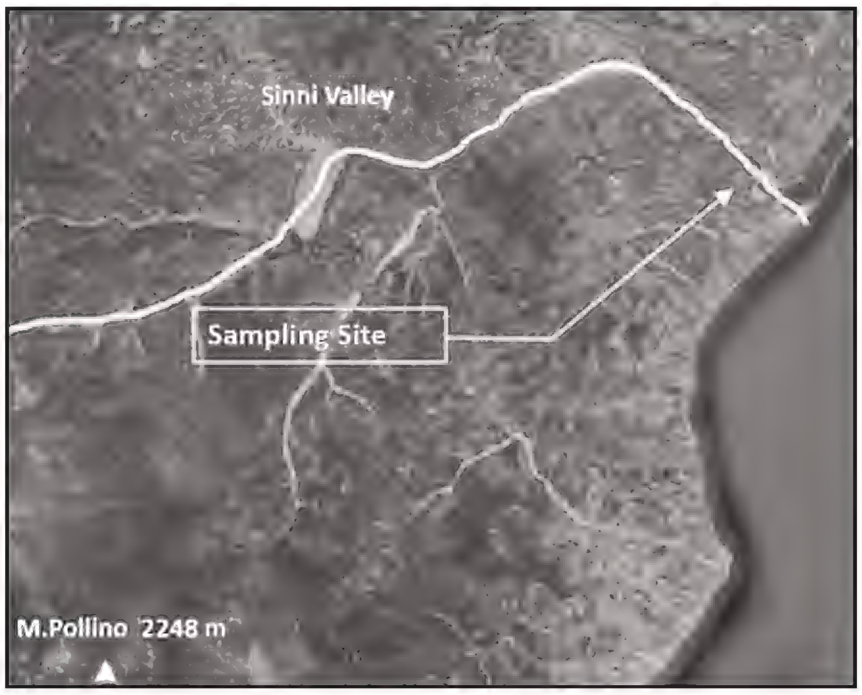

Figure 1. Localisation of the sampling site.

μg/ m³	average	std	min	max
OC	**1.66**	0.55	0.82	2.94
EC	**0.42**	0.23	0.12	1.04
Cl^-	**0.48**	0.33	0.03	1.66
NO_2^-	**0.16**	0.04	0.06	0.26
NO_3^-	**0.51**	0.24	0.20	1.17
SO_4^{2-}	**1.90**	0.81	0.54	3.78
Na^+	**0.764**	0.151	0.479	1.120
NH_4^+	**1.020**	0.505	0.148	2.279
K^+	**0.112**	0.049	0.015	0.212
Mg^{2+}	**0.023**	0.017	0.015	0.092
Ca^{2+}	**0.097**	0.108	0.015	0.481

Table 1. Average, standard deviation, minimum and maximum for each sampled component.

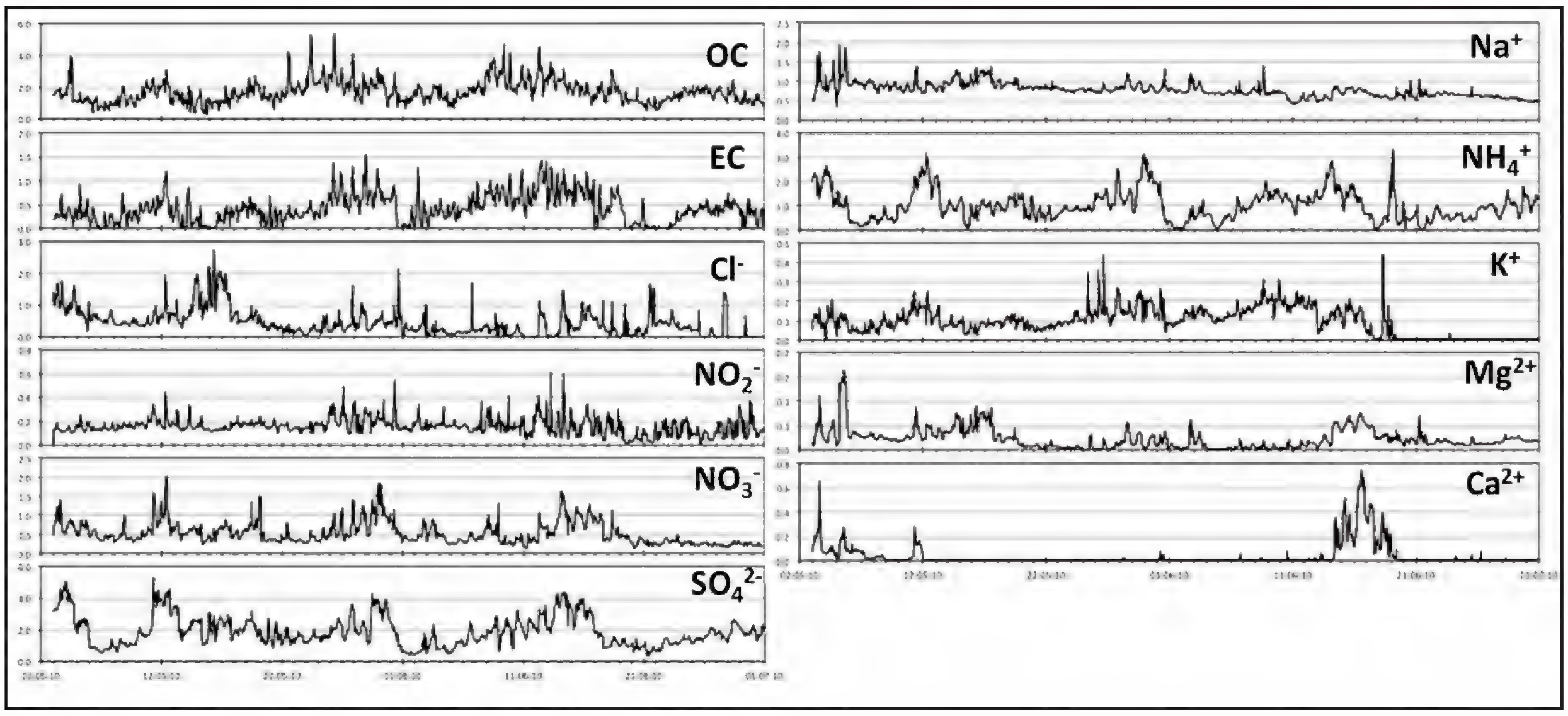

Figure 2. Species' time series.

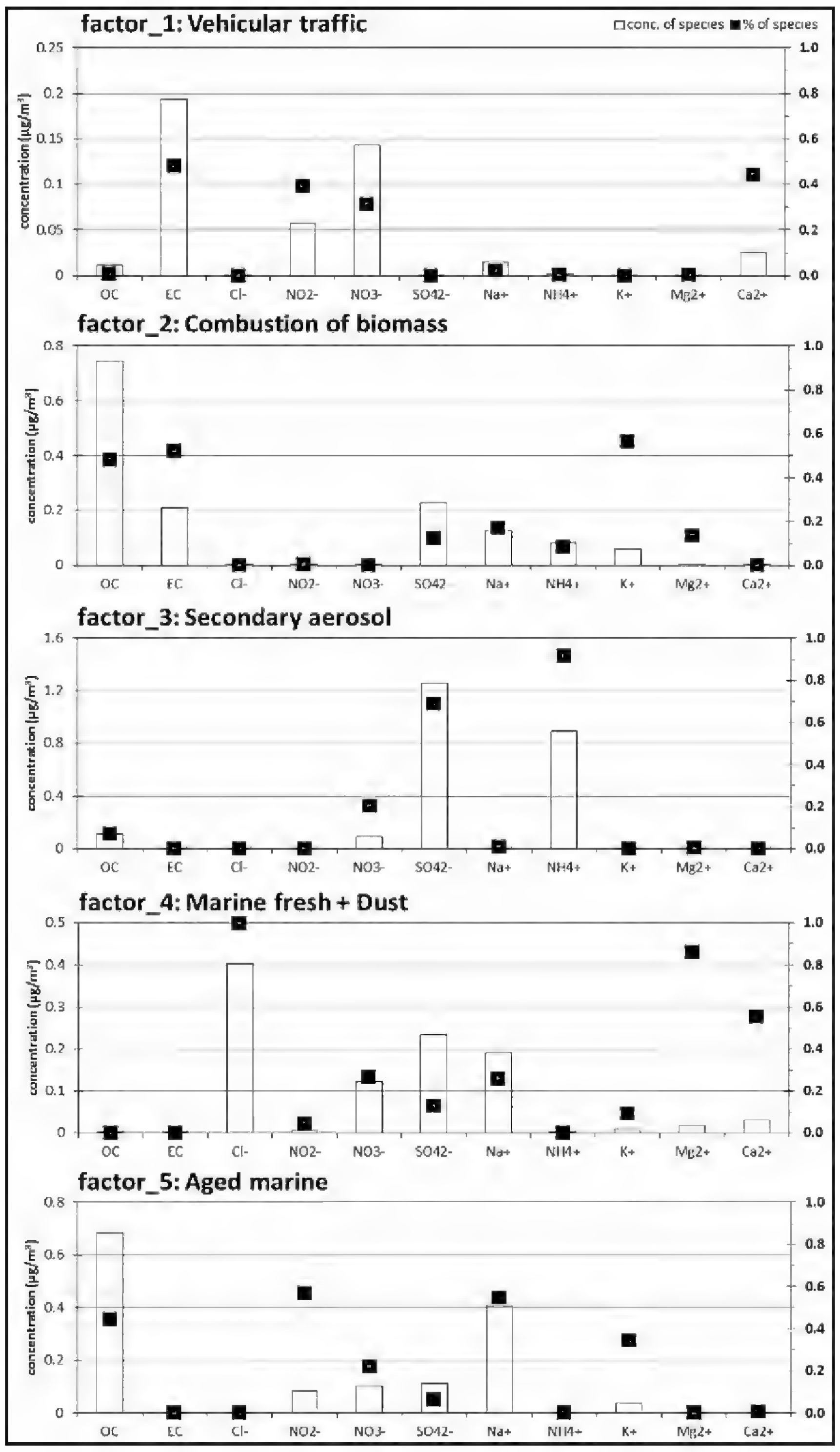

Figure 3. Individuated factors through PMF analysis.

with PMF explains the correlation between the variables observed through their linear combinations called "factors", associated to sources, which originate from common latent characteristics of the observed variables. The input model needs certain defined parameters such as the errors associated with the individual specimen and the number of factors in which clustering the experimental data, corresponding to the theoretically expected sources.

RESULTS AND DISCUSSION

The figure 2 shows sampled species' time series, where is noticeable the high variability of the values along the sampling period and the Table 1 shows a summary of mean, standard deviation, minimum and maximum for each sampled component, highlighting also how low are concentrations.

For the case studied, the PMF analysis permitted to individuate and recognise 5 factors (Fig. 3), as follows.

The first factor is Vehicular traffic with a high percentage of EC, NO_2^-, NO_3^-, linked to vehicular exhaust emissions, together with the presence of Ca^{++} related to road resuspension. Another recognized factor was the Combustion of biomass with high percentage of organic carbon, elemental carbon and potassium, all components derived from combustion processes. A third emission factor has been identified as Secondary aerosol with prevalence (high % contribution) of sulfate and ammonium as well, so a secondary aerosol present as ammonium sulfate. Another factor was composed of Marine fresh aerosol and Dust, with a very high value of chlorine (which characterize the fresh marine aerosol component) associated to a high value of sodium, and the presence of magnesium and calcium associated to both marine and sand transport. The fifth factor was the so-called Aged marine, defined as such because differently than the fresh marine presents no chlorine (which comes to be lost rapidly) but only the sodium. This factor is mixed with a component of anthropogenic nature, as evidenced by the organic carbon and nitrite (both of non-marine origin) probably carried by the wind at the time of the air masses displacement.

In the Figure 4 are presented for each factor the time series along the whole sampling period (left) and the trends within the 24h-cycle (right).

Vehicular traffic presents a bimodal trend almost coincident with the main hours of moving vehicles: around 6:00–7:00 a.m. and 8:00 p.m.,

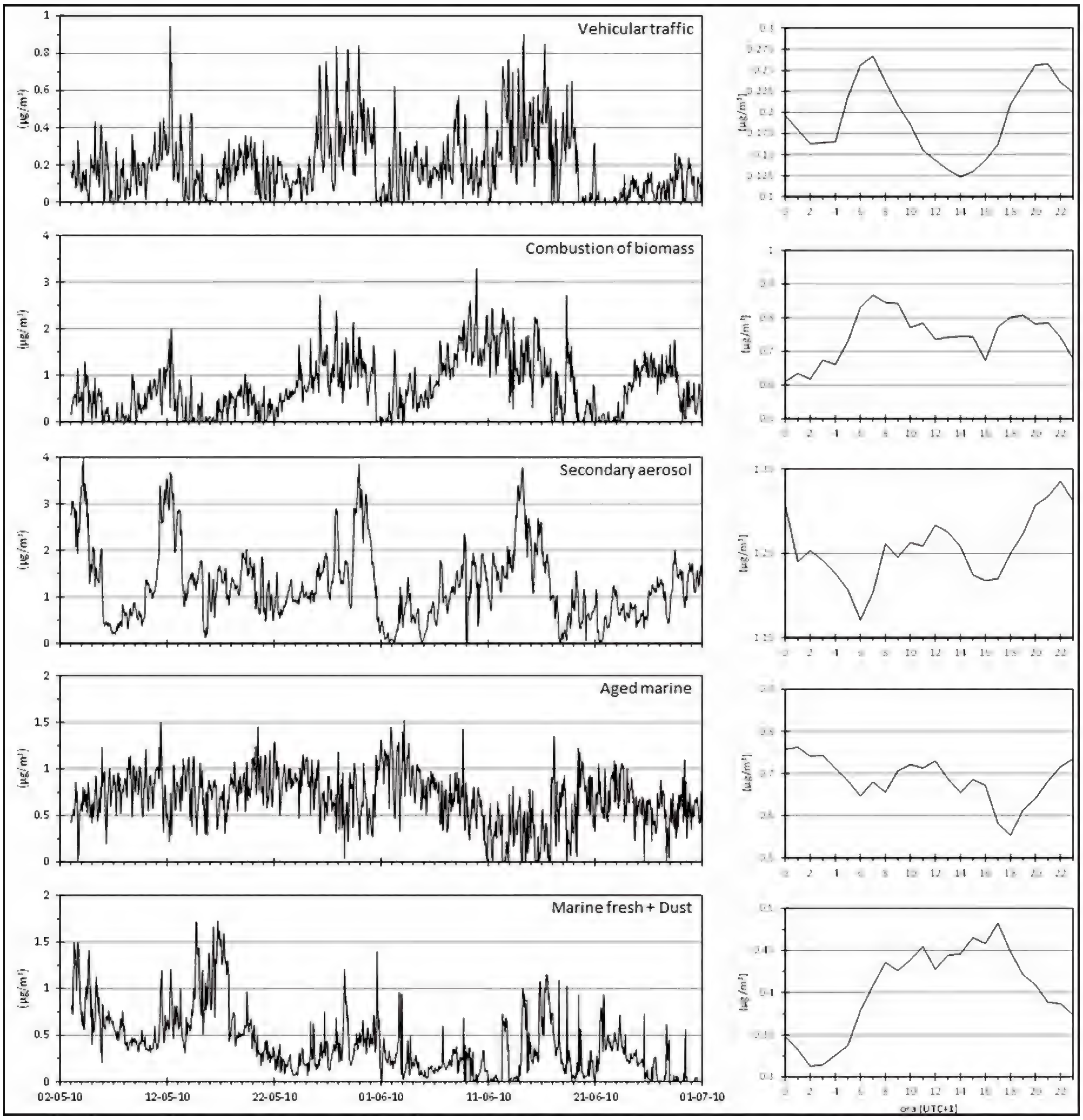

Figure 4. Time series and 24h-cycle of each factor.

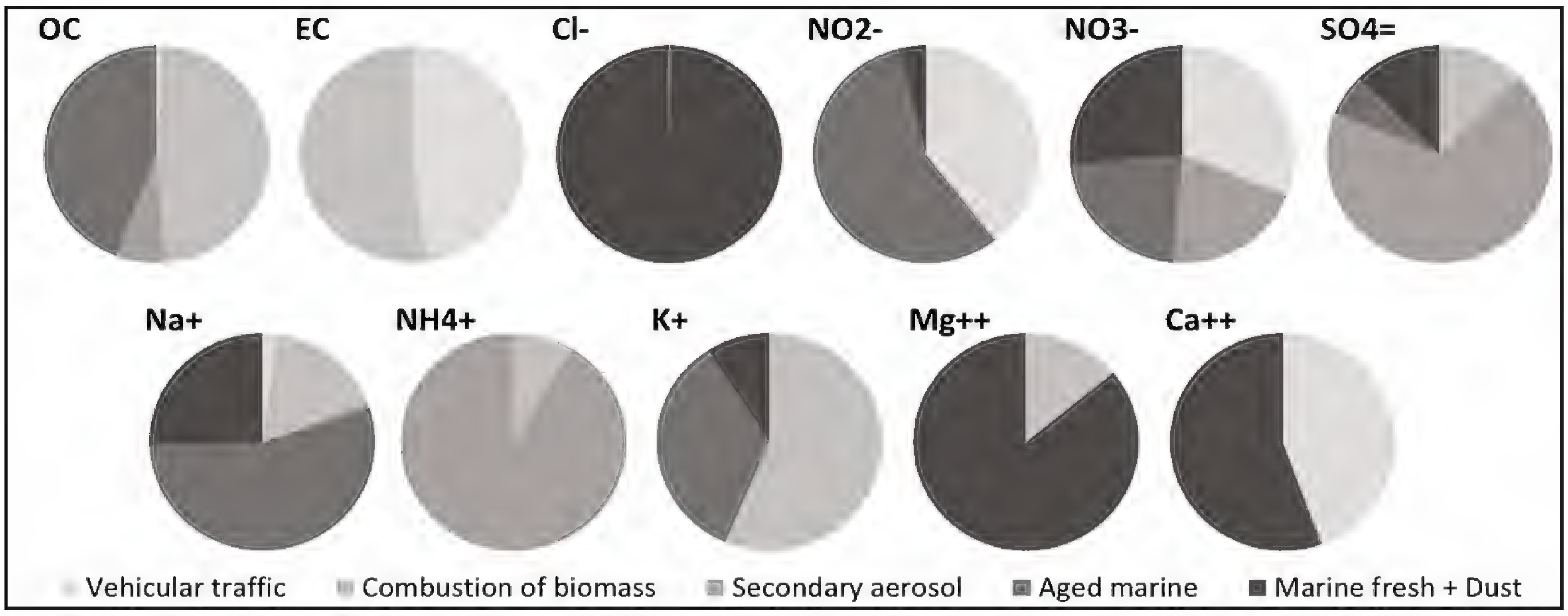

Figure 5. Contribution % of each species to the 5 factors.

when traffic flows are greater, the Vehicular traffic factor has the highest values. Combustion of biomass, probably connected to agricultural activities such as stubbles burning, has higher concentrations during the daytime. Secondary aerosol has daily changes that can be associated with both photochemical processes and movements of air masses involving the area. Marine fresh and Aged marine are obviously influenced by sea-land breezes, so when the breeze blew from the sea during the day the highest concentrations of Marine fresh were recorded; when the breeze blew from the land, Aged marine returns as the air masses are beckoned.

Also, as mentioned before, it was made a differentiation into three periods cumulating the days similar according three main anemological situations: 24 days combined with a NW perturbation; 16 days combined with situation of local breeze; 19 days combined with local breeze to which is associated a transport of sand. In the period when the perturbation comes from NW, so the Tyrrhenian, the wind is stronger, while in situations of local breeze and sand transport the wind maintains lower speeds.

What happens to individual sources during various anemological typologies. Vehicular traffic as expected shows bimodal daily trend similar in the all three periods although concentrations are different; this factor occurs with lowest values throughout NW perturbation maybe depending from dispersion and dilution concerns, in consideration that the height of the mixing layer is greater during the periods of perturbation. Combustion of biomass concentrations are lower as well during NW perturbations, again probably because of greater dilution; it shows within the 24h-cycle higher values more during daytime because of human activity. Even Secondary aerosol is lower during NW perturbation, with an almost constant trend over the 24 hours; therefore this secondary aerosols is likely associated with a regional background pollution. Aged marine increases during the NW perturbation because maybe linked to marine aerosol from the Tyrrhenian that depletes chlorine during the way; in this factor are also present components related to pollution from human activities (eg. OC, NO_2^-) because they are probably dragged by air masses passing through the mainland. Marine fresh aerosol shows higher values during the periods of local breeze and sand transport for accumulation-dilution question and with 24h-cycle increasing in daytime according to sea-land breeze phases.

Then, other data of most interest is the percentage contribution of each species to the 5 factors (Fig. 5) where it is seen that some components enter more in certain factors rather than in others like for example the $SO_4^{=}$ which most enters into Secondary aerosol, or as the chlorine which enters completely into Marine fresh; instead other components such as NO_3^- are distributed in several factors more or less abundantly in one rather than in another.

Finally, regarding the contribution of the 5 factors on the total $PM_{2.5}$ detected, it is seen that the main factor in terms of mass is attributable to Secondary aerosol with 30%, then follows Combustion of biomass with 22%, then Aged marine with 21%, then

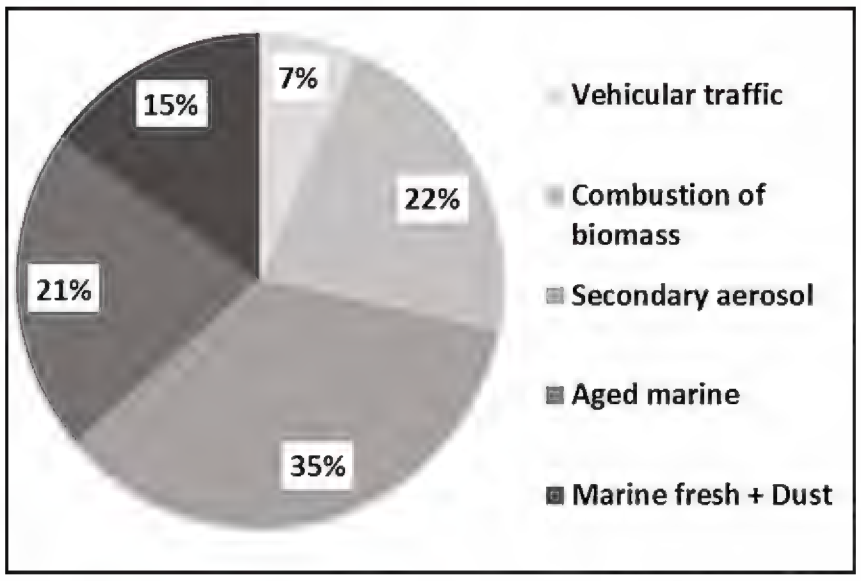

Figure 6. Contribution of the 5 factors on the total PM2.5 detected.

Marine fresh & Dust with 15%, and finally Vehicular traffic with 7% (Fig. 6).

CONCLUSIONS

In general the source apportionment techniques, through multivariate statistical analysis, allow to have information about air pollution factors that insist on a specific area, with the possibility of differentiating anthropogenic sources and natural sources, and discriminating primary and secondary sources. In particular for a rural background site, as this study case, PMF model leads to the predetermination of factors although the concentrations of species are highly variable and near to the detection limit. The use of PMF model is therefore to be considered a valid basis for the identification of the most probable emission profiles at a site where the sources are not particularly evident; hence it becomes essential to improve that receptor analysis with weather studies, in particular anemology and mixing layer height both locally and regionally. For certain investigations as our situation is eventually important rather temporal trends with cycles in the short and medium term as well as occasional events, and high-time resolution monitors can provide an important contribution to the identification of potential emission sources *a fortiori* in case of limited number of parameters and limited sampling period.

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MONOGRAPH

Seafood species identification by DNA barcoding, a molecular tool for food traceability

Venera Ferrito & Anna Maria Pappalardo

Department of Biological, Geological and Environmental Sciences - Section of Animal Biology "M. La Greca", University of Catania, Via Androne 81, 95124 Catania, Italy; e-mail: vferrito@unict.it; pappalam@unict.it

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ABSTRACT Traceability contributes to improve food safety giving information on animal species, origin, authenticity, composition and production system. Species identification is an important step of seafood traceability and molecular tools have been proved far superior to all other diagnostic methods previously used. The seafood products are particularly affected by commercial frauds based on unintentional or deliberate species substitutions of low value fish species for high value fish. In this review, we summarize the data concerning the level of fish species misidentification in processed products in the Italian fish markets and strengthen that DNA barcoding is an effective molecular tool to track down mislabeling and food frauds. Furthermore, we highlight the COIBar-RFLP (Cytochrome Oxidase I Barcode-Restriction Fragment Lengh Polymorphism), combining two consolidated techniques (COI barcoding and PCR-RFLP) in a new molecular strategy as a rapid method for routine screening to detect the mislabeling of seafood products.

KEY WORDS COIBar-RFLP; DNA Barcoding; Frauds; Seafood products.

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INTRODUCTION

The fish trade globalization and the increased demand for fishery products, have raised important concerns about the food authentication due to the alarming levels of seafood mislabeling worldwide detected (Garcia-Vazquez et al., 2011; Changizi et al., 2013; Helyar et al., 2014; Huang et al., 2014; Armani et al., 2015; Benard-Capelle et al., 2015; Lamendin et al., 2015). As a result, a high and growing interest in the origin of seafood products has been triggered in consumers who demand for food quality and safety assurance. In this context, seafood traceability has become very important to respond to the consumers demand to know what they eating. According to the European Union (EU) regulation 178/2002, traceability is the ability to track any food through all stages of production, processing and distribution (including importation and at retail). More specifically, product tracking is the process that follows the product from upstream to downstream (from beginning to the end) so that, at every stage of the process, appropriate traces or informations can be supplied. Product tracing is the reverse process of the food supply chain, or a method in gathering the informations previously released (Fig. 1). Therefore, traceability contributes to improve food safety giving information on animal species, origin, authenticity, composition and production system.

Focusing on species identification, that is an important step of seafood traceability, advances in molecular biology technologies opened new avenues in the field of food-safety, offering new analytical controls suitable both to enhance the food-safety and food-authenticity of foodstuff for humans and to detect frauds. The reliability and sensitivity of species authentication through molecular biology techniques is far superior to all other diagnostic methods previously used, since it is based both on the study of genes, from which the uniqueness that characterizes all living things, and on stability of DNA to every kind of treatment that is used in the food processing industry. In particular, molecular biology tools allowed to exceed the limits of the morphological approach in species identification. The morphological identification of gross anatomical features of the whole fish according to dichotomous key proposals by the Food and Agriculture Organization (FAO), has represented, for example in Italy, the only method used in identification of fish species as legal standard of value. However, a growing scientific literature dealing with seafood products authentication has demonstrated that the highly automated biomolecular techniques can greatly improve species identification in processed seafood products, especially when due to the industrial processing, species lose those morphological characters useful to recognize them. Multiple marker types (mitochondrial genes, microsatellites, SNPs) have been submitted to analytical methods such as nucleotide sequencing, fragment analysis and genotyping for species identification in processed products. Among these molecular markers, a partial sequence of the mitochondrial gene cytochrome oxidase I (COI) referred to as a barcode sequence, has been widely used for fish species identification in transformed fishery products (Ogden, 2008). The COI DNA barcode has been validated for forensic species identification (Dawnay et al., 2007) and is currently being used to differentiate between animal taxa enabling discrimination for more than 98% of animal species (e.g., Hebert et al., 2003a, b; 2004; Paquin & Hedin, 2004; Ward et al., 2005; Hajibabaei et al., 2006; Lefebure et al., 2006). Based on considerations above, and considering that the new food habits have led to an increased consumption of fresh or frozen cuts, processed and ready to eat food, making species identification very difficult, the aims of the present review are:

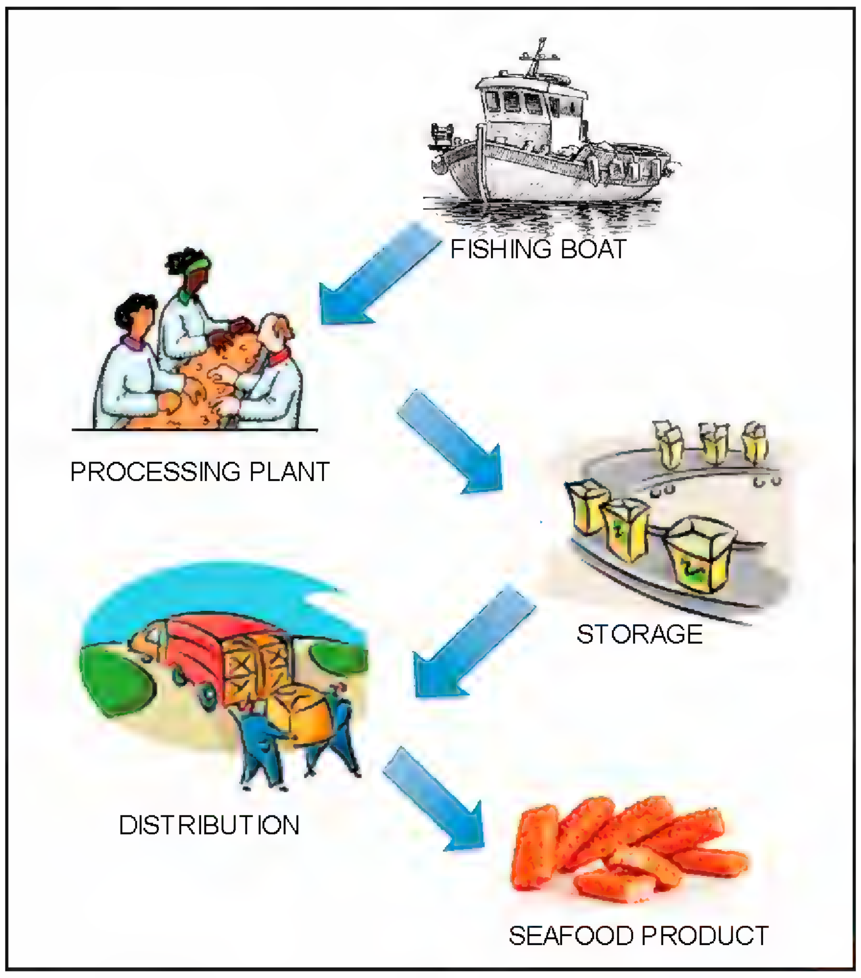

Figure 1. Flowchart of traceability in seafood industry. Arrows indicate product tracking or the process that follows the product from upstream to downstream (from beginning to the end).

1) to summarize the data concerning the level of fish species misidentification in processed products in the Italian fish markets;

2), to strengthen that DNA barcoding is an effective molecular tool to track down mislabeling and food frauds;

3) to recommend the formal adoption of DNA-based procedures for the establishment of effective standardized traceability systems by policy government.

For these purposes, we will describe first the DNA barcoding methodology and then we will report on several cases of fish species substitutions. Finally, we will deal with analytical approaches allowing to improve the rapid identification of species in convenience seafood useful for routine species identification by local authorities.

DISCUSSION

DNA barcoding as a prime tool of species authentication

Over the last decade, DNA barcoding has

emerged as a universal method to identify living organism. It is based on the sequencing of a short and standardized gene region for the recognition and identification of animal species. However, DNA barcoding does not seek to throw away the morphological studies in support of a narrow and entirely molecular identification system. The overall purpose is to build an alliance between molecular and morphological taxonomists for rapid and unequivocally species identification (Bhattacharya et al., 2015). The quest for a genetic marker useful to determine unambiguously the species is still a matter of debate. Such a genetic marker should have several features. It should show high interspecific but low intraspecific variation to avoid ambiguities in the authentication of species. From the technical point of view it should be characterized by well-preserved PCR-primer sequences at the borders, to guarantee PCR amplification reliable, reproducible, productive and without the risk of producing false negatives, especially in a cluster analysis. Tipically, mitochondrial genes are used for DNA barcoding in animal: the mtDNA has a higher rate of mutation compared to the nuclear genome, is maternally inherited, has a high copy number, which promotes PCR amplification (Hebert et al., 2004). The best candidate to this role has been proposed to be, at least for animals, an approximately 648 bp region, near the 5' end of the mitochondrial Cytochrome Oxidase I (COI) gene, a highly conserved, bioenergetic gene encoding for protein subunits of the respiratory chain and is referred as a "barcode sequence" (e.g. Hebert et al. 2003a, b, 2004; Paquin & Hedin, 2004; Ward et al., 2005; Pappalardo et al., 2011; Pappalardo & Ferrito, 2015a, b; Pappalardo et al., 2015). This gene region generally shows little variation within species but substantial divergence between species, allowing for taxa differentiation (e.g. "barcoding gap") (Mayer & Paulay, 2005). The Consortium of Barcode of Life (CBOL) has indicated this sequence, also know as the "Folmer region", to be the reference barcode for animal organisms. Until now, the adoption of COI as a DNA barcode has been successful in the species identification and in the discovery of cryptic species among amphibians (Vences et al., 2005), ants (Smith et al. 2005), birds (Hebert et al., 2004), collemboles (Hogg & Hebert, 2004), fishes (Ward et al., 2005), mots and butterflies (Ball & Armstrong, 2006; Hajibabaei et al., 2006) and spiders (Barret & Hebert, 2005). Most of this studied species (>94%) showed well separated barcodes, suitable for identification purpose (Ward et al. 2005; Hajibabaei et al., 2006). Generally, two approaches have been employed to analyze DNA barcode sequences and to verify the identity of unknown samples: a similarity search which is conducted with the DNA Identification Engine at BOLD (Barcode of Life Database), based on the Hidden Markov Model (HMM) algorithm (Eddy, 1998), and BLAST algorithm of GenBank (Altschul et al., 1990); and the Neighbour-Joining (NJ) trees built with a distance-based approach to illustrate sequence identity based on tree topology. However, conventional DNA barcoding encounters a problem: DNA degradation in processed biological material often prevents the recovery of PCR fragments longer than 200 bp, impeding full barcode recovery (Hajibabaei et al., 2006). Some authors have proposed the use of a "mini-barcode" sequence to overcome this problem. The mini-barcode system dramatically broadens the applications of DNA barcoding and several authors as Meusnier et al. (2008) have demonstrated that shorter barcode sequences (< 150 bp) represent efficient tags for species identification. According to Ferri et al. (2015) the power of the DNA barcoding is to merge in a single approach the molecularization of identification process, the standardization of molecular markers and analytical procedures and the data computerization of identification results. Information gathered from DNA barcodes can be used across many fields of biology, where species identification play a central role, including ecology, conservation biology, biosecurity, medicine and pharmacology (Pečnikar & Buzan, 2014). Furthermore, a relatively recent and important application aspect of DNA barcoding method concerns the food safety, since the rapid and accurate species identification through this promising tool has proved very useful to detect potentially frauds particularly in transformed seafood products.

Fish market frauds

In the last ten years, a large number of scientific reports have highlighted that fraudulent fish species substitution based on willful or unintentional substitution of low value fish species for high value fish, is common in processed products, such as fillets and transformed products, due that the morphological identification of the processed species is very difficult or impossible. More specifically, the recent literature deals with the proper identification of species contained in food through the DNA barcoding methodology (Barcaccia et al., 2015) and several investigations have been carried out on seafood products from various marketed brands and on samples purchased in fish marketplaces.

The Italian markets have been investigated to verify the label information of several seafood products. For example, 69 samples of fresh and frozen fish fillets obtained from department stores and fishmongers of four different regions of Northern and Central Italy (Emilia-Romagna, Liguria, Tuscany and Latium) were investigated for label information trough COI DNA barcoding (Filonzi et al., 2010). It was shown that the identified species did not matched with the ones declared on label in 22 samples (32%). The amount of commercial frauds in the trading of shark slices labeled as "palombo" in Italian markets, was evaluated by Barbuto et al. (2010), which highlighted a relevant economical impact for consumers. Indeed, the recognition of commercialized shark species through the DNA barcoding approach showed a high amount of commercial frauds rising the 80% of analysed "palombo" slices. Studies by Nicolè et al. (2012) used a multi-locus DNA barcoding strategy for genetic identification of the marine species present in 37 seafood products (30 fish, 3 crustacean and 4 mollusk samples) some of which were fresh or frozen skinned fillets, or heat treated or canned samples. The results of this study showed that the identified species of five samples (13.5 %) did not matched the label information and supported the use of CO1-based identification of fish sample as an efficient tool for food authentication.

More recently, Cutarelli et al. (2014) ascertained possible labeling frauds, made substituting value species with less precious ones, in 58 Italian commercial seafood products from Southern Italy markets (40 samples were whole fish caught in the Mediterranean Sea and 18 samples were commercial fish products). No mislabeling was found for the whole fish sample, while two important frauds were detected in transformed products (11.1%): in a sample sold as cod fillets in butter, the species *Gadus macrocephalus* Tilesius, 1810 (Gadiformes Gadidae) and *G. morhua* Linnaeus, 1758 were substituted by the less valuable species *Pollachius virens* (Linnaeus, 1758), and in a sample sold as frozen grouper fillets that were made of halibut, *Reinhardtius hippoglossoides* (Walbaum, 1792) (Pleuronectiformes Pleuronectidae), instead of grouper, *Epinephelus marginatus* (Lowe, 1834) (Perciformes Serranidae). A 56.6% of mislabeling (17 products out of 30) was reported by Tantillo et al. (2015) for *Merluccius merluccius* (Linnaeus, 1758) (Gadiformes Merlucciidae) or European hake fillet in Southern Italy (Apulia), while only 5% of mislabeling (6 sample on 120) was detected by Di Pinto et al. (2016) in the same region (Apulia) in packaged frozen fishery products sold as breaded hake cutlets, croquettes and sticks, and breaded plaice fillets in market, supermarket and hypermarket chains. However, it would be noted that none of the products analyzed by Di Pinto et al. (2016) declared the presence of *M. merluccius* on the label, suggesting that the substitution of the European hake, when it occurs, is deliberate (Ferrito et al. 2016). The screening of forty fresh and frozen fillet samples labeled as European plaice, *Pleuronectes platessa* Linnaeus, 1758 (Pleuronectiformes Pleuronectidae) and common sole, *Solea solea* (Linnaeus, 1758) (Pleuronectiformes Soleidae) randomly purchased at several supermarkets in Sicily and Calabria, allowed to detect mislabeled products both for European plaice (35 % of the cases) and common sole (41 % of the cases). *Pleuronectes platessa* was replaced by *Platichthys flesus* (Linnaeus, 1758) (Pleuronectiformes Pleuronectidae), *Limanda limanda* (Linnaeus, 1758) and the river fish *Pangasius hypophtalmus* (Sauvage, 1878) (Siluriformes Pangasiidae); *Solea solea* was replaced by *Arnoglossus laterna* (Walbaum, 1792) (Pleuronectiformes Bothidae) (Pappalardo & Ferrito, 2015a).

Toward a common strategy for a rapid identification of fish species: the COIBar-RFLP

Recently, two consolidated methods including COI barcoding and PCR-RFLP were combined in a new molecular strategy (COIBar-RFLP, Cytochrome Oxidase I Barcode-Restriction Fragment Lengh Polymorphism) for fish species identification in processed seafood products (Pappalardo & Ferrito, 2015b; Ferrito et al., 2016) (Fig. 2). The aim was to perform a rapid and easy molecular approach

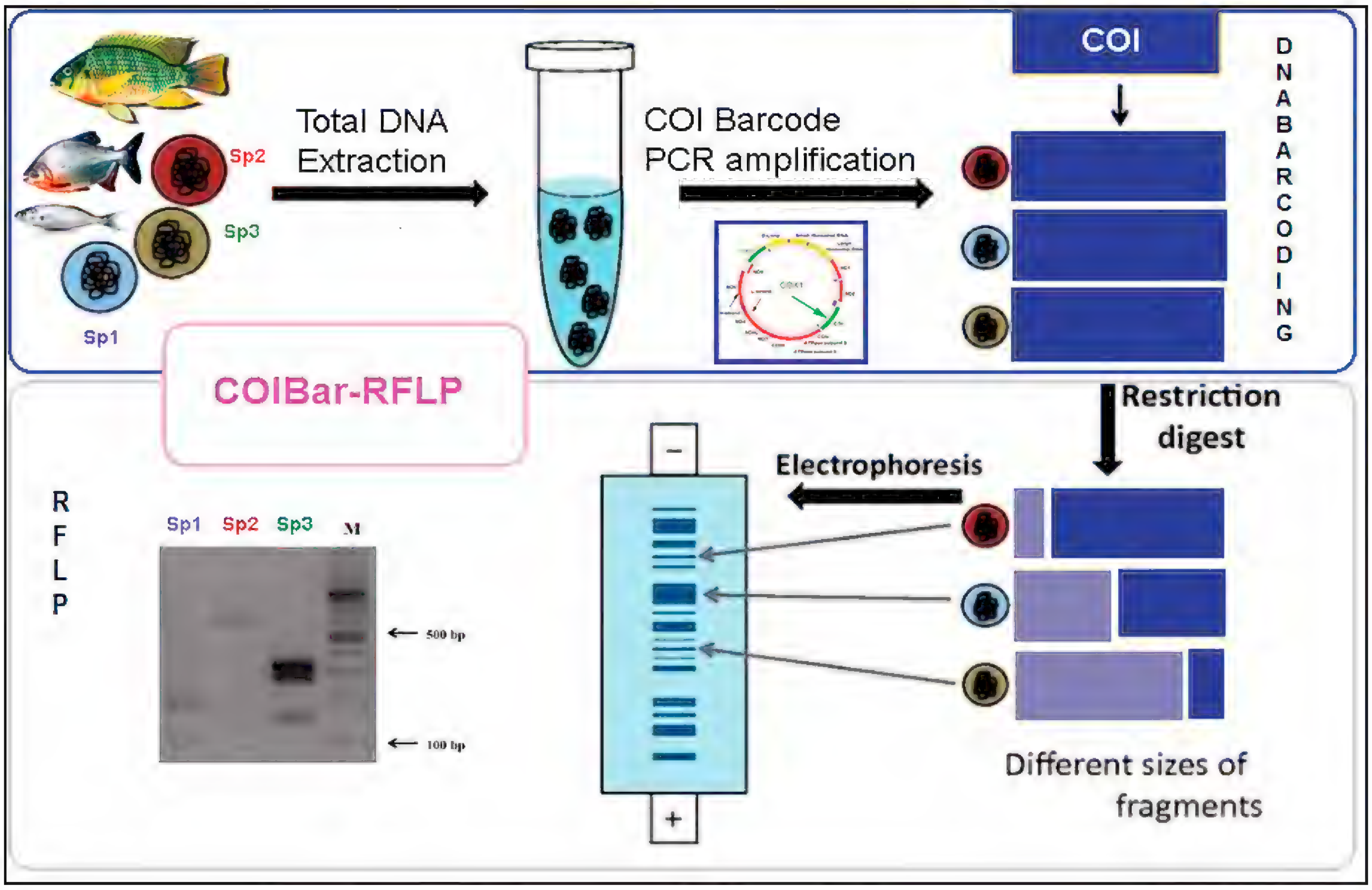

Figure 2. Diagram summarizing the steps of the DNA barcoding method (above) and of the RFLP (Random fragment Length Polymorphism) method (below) combined in the COIBar-RFLP strategy.

by using the conventional DNA barcoding and a traditional PCR-restriction fragment length polymorphism method to unveil potential mislabeling commercial frauds. Emerging molecular techniques have recently been used for seafood fish species identification, but most of them are currently only available for use by specialists in specially-equipped laboratories and they include very expensive methods such as real-time PCR, microarray technology, and next-generation sequencing (NGS) (e.g. Balitzki-Korte et al., 2005; Kochzius et al., 2008; Teletchea et al., 2008; Helberg & Morrissey, 2011; Pascoal et al., 2012; Chuang et al., 2012; Li et al. 2013; Prado et al., 2013). On the other hand, PCR-restriction fragment length polymorphism (PCR-RFLP) has proven to be a practical, simple and rapid technique (Partis et al., 2000) and a high level of expertise in molecular genetics is not necessary for interpreting results obtained on agarose gels. In RFLP analysis, the DNA is cutted into fragments by restriction enzymes and the resulting restriction fragments are separated according to their lengths by gel electrophoresis. Therefore, PCR-RFLP may be considered a suitable technique for routine species identification in processed fishery products, showing excellent potential even in the case of mixtures of species (Rea et al., 2009).

The COIBar-RFLP analysis was applied to investigate labeling accuracy in processed anchovy products to unveil putative fish fraud involving the replacement of the European anchovy, *Engraulis encrasicolus* (Linnaeus, 1758), with less valuable Engraulidae and Clupeidae species (Pappalardo & Ferrito, 2015b). Four different species, *E. encrasicolus*, *E. japonicus* (Temminck et Schlegel, 1846), *Sardinella aurita* Valenciennes, 1847 and *Sardina pilchardus* (Walbaum, 1792),were found in the processed products labeled as European anchovy and the COIBar-RFLP yielded differential patterns of MboI restriction sites allowing the unambiguous discrimination of European anchovy from the other species. The COIBar-RFLP was also performed for white fish authentication in convenience seafood (Ferrito et al., 2016). In conflict with the Italian Ministerial Decree (MD) of January, 31, 2008 stating that fish products labeled as hake must contain only the species *M. merluccius*, four species, *Gadus chalcogrammus* Pallas, 1814, *M. merluccius*, *M. productus* (Ayres, 1855) and *M. paradoxus* Franca, 1960, were found in 30% of products (frozen breaded steaks and fish fingers) collected from Southern Italy markets and labeled as hake. The restriction enzyme HinfI yielded differential digestion patterns suitable to discriminate the four species and to unveil inconsistencies between product labels and genetic species identification.

CONCLUSIONS

Mislabeling detected through molecular tools has been reported for seafood products worldwide (e.g. Garcia-Vasquez et al., 2011, Chanzigi et al., 2013, Galal-Kallaf et al., 2014, Benard-Capelle et al., 2015, Carvalho et al., 2015, Cawthorn et al. 2015, Lamendin et al., 2015). In particular, COI DNA barcoding has been adopted by the United States Food and Drug Administration (FDA) as the primary method of regulatory control of seafood products in the United States (Handy et al., 2011); by the governmental Brazilian Consumers Protection Agency for application of financial penalties, due to detection of mislabeling and species substitution in seafood products (Carvalho et al., 2015); and in Canada, which is in the process of incorporating DNA barcoding into its regulatory framework for fish species authentication (Clark, 2015). The incorporation of DNA barcoding methods of identification for law enforcement in the Italian food control system, although inevitable in the future, today remains a challenge (Ferrito et al., 2016). We hope for the formal adoption of DNA-based procedures for the establishment of effective standardized traceability systems in Italy, and in this context we encourage local authorities to carry out pilot projects on the effectiveness of traceability molecular tools such as COIBar-RFLP for routine screening to detect the mislabeling of seafood products.

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MONOGRAPH

Survey on the presence of phlebotominae sandflies in eastern Sicily and connected risk of leishmaniasis

Oscar Lisi, Valerio Vaccalluzzo & Vera D'Urso

Department of Biological, Geological and Environmental Sciences - Section of Animal Biology, University of Catania, via Androne 81 - 95124 Catania, Italy
Corresponding author, e-mail: olisi@unict.it

ABSTRACT The authors summarize the results of all the searches for phlebotomes in eastern Sicily, including the connected risk for humans and dogs to contract leishmaniasis, and point out the current situation with new risks, and the main goals for present and future research.

KEY WORDS Phlebotomes; *Phlebotomus sergenti*; *Leishmania tropica*; leishmaniasis; Eastern Sicily.

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INTRODUCTION

Sicily is a region in which sandflies are much widespread and leishmaniasis is endemic, falling into the small group of Italian regions with highest values of incidence of the disease; this is always due to *Leishmania infantum* Nicolle, 1908 (Trypanosomatida Trypanosomatidae), responsible for all kinds of leishmaniasis, both human and canine, its main vector is *Phlebotomus perniciosus* Newstead, 1911 (Diptera Psychodidae), present in all environments, followed by *P. perfiliewi* Parrot, 1930, whose role as vector is practically limited to rural environments with sufficient presence of farm animals. Two forms of human leishmaniasis are known in Italy; visceral leishmaniasis (VL) is a very serious illness which invariably requires hospitalization; from about 10 to more than 40 new cases/year in Sicily are reported to the Ministry of Health. Cutaneous leishmaniasis (CL) does not require hospitalization and always has benign esit, therefore it is often non-denounced or even non-recognised (Gradoni, 2013); for this reasons, though the number of new cases/year recorded is more or less similar to VL, it is believed that the real incidence is far higher.

Among the possible factors determining such a stable situation of the disease, well rooted in the territory, one can record the very high number of infected dogs, constituting the parasite reservoir, the increasing number of persons with immunodeficiency and of travellers and migrants accross the Mediterranean, and the effects of global warming, which have had a positive influence on the vectors' survaillance and distribution.

STATE OF ART

The first study on phlebotomes in Sicily was due to Adler & Theodor (1931), who carried out a very important pioneering investigation on several foci of leishmaniasis in the Mediterranean, including the town of Catania, in which they found *P. perniciosus*, *P. neglectus* Tonnoir, 1921, *P. sergenti* Parrot, 1917, *P. papatasi* Scopoli, 1786 and *Sergentomyia minuta* (Rondani, 1843). They concluded that the main vector had to be *P. perniciosus* and observed that the distribution of the disease and the vector were rather inhomogeneous in the town, anyway with more incidence in the periphery than the centre of the town.

Unfortunately, the results of their research, especially as regards the phlebotome species composition, were misrepresented by the fact that the authors based their search for phlebotomes mostly inside sick person's houses, without taking into appropriate consideration the environments of adult emerging and daytime shelter of these insects out of houses.

Biocca et al. (1977) reported the results of their collections in many sites all over Italy, with a few data also on Sicily. Among the others, they found *P. perniciosus* (30.6% of the specimens), *P. perfiliewi* (20.0%), and, only in Sicily, *P. sergenti* (0.1%). They confirmed *P. perniciosus* as the main vector of leishmaniasis in Italy and noticed its ecological plasticity, finding it in various habitats and from 0 to 1000 m a.s.l.. They reported *P. perfiliewi* in Sicily as vector for CL. They also found the very common and abundant species *S. minuta* (47.8%), which however stings mostly anphibians and reptiles and is not involved in the transmission of *Leishmania* Borovsky 1898 (Ross 1903) for humans or dogs.

After 70 years from Adler's and Theodor's investigation, finally the attention focused again on Sicily, thanks to Ruta et al., 2002, who carried out a research in the hinterlands of Catania and Siracusa; they collected more than 2000 specimens, and found collectively *P. perniciosus* (50.4%), *P. neglectus* (0.3%), *P. papatasi* (0.2%), *P. sergenti* (0.3%) and *S. minuta* (48.8%); however, it must be stressed that in a site they found about 90% of *P. perniciosus*. The authors observed a flight season from May to, in some sites, November (October in others), and reported two generations during the flight season, with just a very slight sign of a third generation in the sites with the longest flight season, immediately stopped by the incoming of the cold season.

They stated that temperature and photoperiod proved to be important to determine start and end of the flight season, while during it humidity proved to be the most important factor which allowed sandflies survival. That a parameter proved to influence the more or less presence of *Phlebotomus* Loew 1845 species with respect to *Sergentomyia* França et Parrot, 1920, the former being more linked to humidity, the latter more resistant to aridity.

Last but not least, the authors remarked on the fact that the risk of transmission of leishmaniasis is not constant during the whole flight season, it becoming noticeable later than the appearance of adults (for the fact that they need first to get contact with infected hosts), and the risk becomes maximum in correspondence with the two peaks of phlebotome density during the season. The authors found more phlebotomes close to the coast then in inland, thus determining a different risk.

D'Urso et al. (2002) performed a research in Catania, Siracusa and Ragusa provinces during the triennial 1997–99, collecting more than 10,000 specimens. They found, collectively: *S. minuta* (63.6%), *P. perniciosus* (34.7%), *P. sergenti* (1.7%) and lastly, *P. neglectus*, *P. papatasi* and *P. perfiliewi* (<1%). Though not very high percentage, they found more frequently *P. sergenti* than in the previous searches, and the authors remarked on the fact that this species, though not in Italy, transmits *L. tropica* in other Mediterranean countries.

The authors did not find noticeable differences in sandflies abundance and species composition linked to different altitudes and distance from the coast, pointing out the role of the specific kind of environment (e.g. more or less anthropized, with different humidity and vegetation, with a different presence of animals). They find on average a difference between the Aetnean area and the Hyblean one, the former being more anthropized and humid with a higher sandfly biodiversity and an important presence of *P. perniciosus*, *P. sergenti* and *P. neglectus*, the latter more rural and dry, dominated essentially by *S. minuta*, therefore with lower risk of leishmaniasis.

The presence of *P. sergenti* in Sicily, induced D'Urso et al. (2004) to focus on this species, analyzing collections in the triennial 1997–99 in one collecting site at the foot of Etna, and another in the Hyblean area. In the former site the authors found 77.7% of *P. perniciosus* and 2.0% of *P. sergenti,* while in the latter, apart from a great deal of specimens of *S. minuta*, *P. perniciosus* was only 14.4% and *P. sergenti* less than 0.02%. The authors pointed out that *P. sergenti* is associated with domestic environments in urban and periurban areas between 0 and 750 m a.s.l. but were not able to comment on a possible role in transmission of leishmaniasis due to the low density found in the studied sites. In any case it is worth to mention that gradually, a scenario was coming out, in which this species was not always so rare as had resulted from the oldest searches.

Another research focusing on *P. sergenti* was due to Maroli et al. (2006), and was practically the continuation of the previous mentioned (D'Urso et al., 2004), which allowed the authors to find an Etnean site in which *P. sergenti* was the dominant species (about 54%). Maroli et al. (2006) sampled in the flight seasons 2004 and 2005 finding that this species had a shorter flight season than *P. perniciosus*, with only one main density peak (i.e. one main generation of adults). They also tested females with blood meal, finding that *P. sergenti* fed mostly on dogs (77.8%), far less on avians (8.3%) and only little on humans (2.8%), while *P. perniciosus* only on dogs (60.0%) and humans (13.3%); however, it must be stressed that in spite of possible preferences, phlebotomes are oportunistic feeders which take their blood meal on the animals more at hand.

Maroli et al. (2005) carried out a research on phlebotome ecology, sampling in 18 sites in various parts of Sicily during 2004 flight season. Among the various environments chosen for putting the traps, they can be recorded: farms with various livestock, chicken pens and wall crevices. They collected a total of 8821 specimens mostly belonging to *S. minuta* (69.9%), while among the *Phlebotomus* species the proportions were: *P. perniciosus* (52.9%), *P. perfiliewi* Parrot, 1930 (46.5%), *P. neglectus* (0.5%), *P. sergenti* (0.1%) and *P. papatasi* (0.03%). The authors pointed out that the two proven vectors of *Leishmania infantum*, *P. perniciosus* and *P. perfiliewi*, were abundant, the former more present in domestic environments, the latter more linked to farm animals (chickens excluded).

Finally, our research group decided to go on with the studies and see what had happened to the phlebotomes in the town of Catania after more than 70 years of urbanistic and sanitary progress, with a series of searches, started with a big monitoring in 51 sampling sites distributed in the urban tissue, in 2006 flight season. A good 45 sites resulted positive for phlebotomes, collecting a total of 4341 specimens, belonging to six species, one of which, *P. mascittii* Grassi, 1908, was new for Sicily. With respect to Adler & Theodor (1931) investigation, the presence of phlebotomes in the town had not only kept more than sufficient for the illnes' maintenance and propagation, but, differently from Adler's and Theodor's results, the sandflies, and in particular *P. perniciosus*, turned out to be abundant also in the centre of the town. Besides, with respect to recent investigations in Sicily (e.g. Ruta et al., 2002), it was observed in some sites a very long flight season: from May to December, with a clear, though lower, third peak in phlebotome density, which means a third generation (D'Urso et al., 2008a, 2009).

In some collecting sites, also *P. sergenti* was abundant: it was found to be up to 45.5% of the specimens, which was the highest percent ratio ever recorded in Sicily (D'Urso et al., 2008b).

Those results induced our research group, in collaboration with a group of colleagues from the "Istituto Superiore di Sanità" (Rome), to make additional investigations in 2008, 2012 and 2013, both in the most interesting sites of Catania, and in several Aetnean sites, integrating the research also with immunological, molecular and cultural techniques in order to analyze females of *Phlebotomus* searching for viruses and *Leishmania*, and about the latter we found that 11% of the investigated females of *P. perniciosus* were positive for genomic *Leishmania* DNA (Lisi et al., 2014); unfortunately it was not possible to determine the species; according to the current knowledge it should be *L. infantum*, but the aim of the investigation was also to check if some exotic *Leishmania* species had been able to reach Sicily and set itself up there, idea justified for several reasons, as it is discussed in the following paragraph.

DISCUSSION AND CONCLUSIONS

As it can be seen, the searches of the last decade have drawn a scenario about the presence of phlebotomes in eastern Sicily, that fully justifies the presence of the illness as endemic, maintained by these insects as vectors, and by the huge number of infected dogs, as reservoir, with the problem of the stray, very numerous and practically out of control.

About the vectors, by comparing the results of the researches of the last ten years, with those of the older ones, it seems that phlebotome flight season has prolonged, and perhaps the species composition of several environments, especially urban, changed, in favour of a more efficient maintainance and propagation of the disease; all this is very probably due to global warming, which seems to have determ-

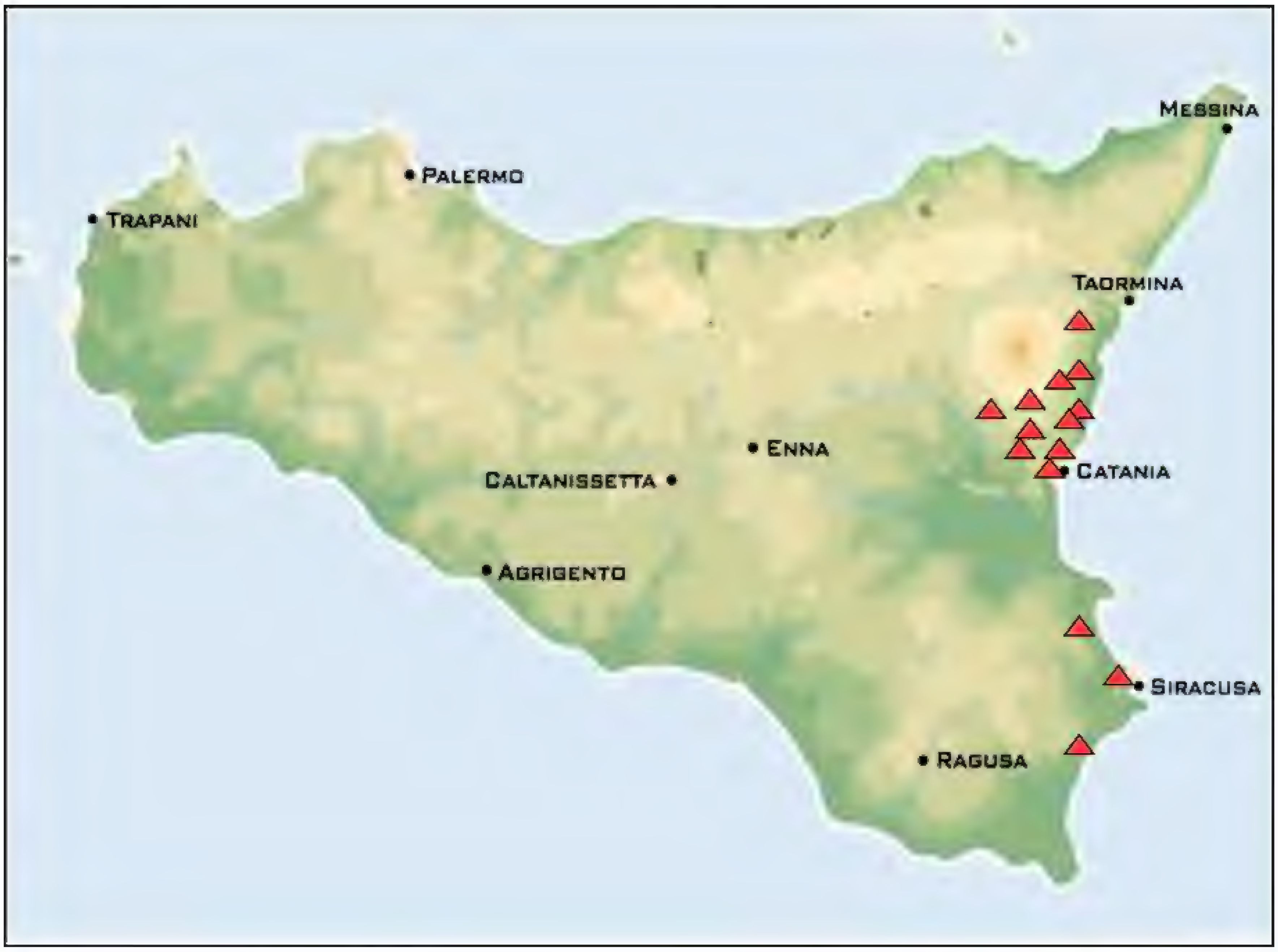

Figure 1. Distribution of *Phlebotomus sergenti* in Sicily according to the literature.

ined the prolongation of the flight season, and, supposedly (the avalaible data are still insufficient to state this with certainty), changes in species composition of some environments, especially the urban, and the general abundance of these insects. Global warming is a process still in act, thus rendering the situation dynamic, and therefore in need to be monitored.

Another very important aspect to which to pay careful attention, is the possibility for some exotic *Leishmania* to reach Sicily and set itself up there finding a species of phlebotome (competent or not for "our" *L. infantum*) suitable as a vector. The island lies in the main immigration route of the "Mediterranean boat people", migrants who fled African and Middle East countries, most of which are endemic for *L. tropica*, because of civil conflicts and/or poverty. Moreover, Catania is located close to the Sigonella NATO military base, where every year soldiers from all over the world (including *L. tropica* Wright, 1903 - endemic Middle East countries) pass through. It is therefore not unlikely that individual infected with *L. tropica* may reach Sicily (this, actually, has already happened), where the presence of *P. sergenti*, the proven vector of *L. tropica* in the countries in which the parasite is endemic, constitutes a high potential risk for introduction of the exotic parasite with the illness it causes. Rioux (2001) demonstrated that populations of *P. sergenti* from Morocco are highly subjected to get infected by *L. tropica*, and Depaquit et al. (2002), while studying the intraspecific variability of different populations of *P. sergenti*, found out that Sicilian and Moroccan populations are "sister groups", thus arising the suspect that Sicilian *P. sergenti* might be as easily infected by *L. tropica* as the Moroccan.

In Italy the distribution of *P. sergenti* seems to be limited to the East coast of Sicily (Fig. 1), but while in the close past it was known only from few Aetnean sites (Adler & Theodor, 1931; Biocca et al., 1977), it then proved to be more spread along the coast not only in the Aetnean territory, but also in the Hyblean area (D'Urso et al., 2002, 2004; Maroli et al., 2006); therefore, with more investigations, it is possible that it will be found in other areas, at least on the island; on the other hand, even if the species were really today present only in eastern Sicily, it is not possible to exclude a colonization of the rest of the island, and of southern Italy.

Besides, though less probable, it cannot be excluded that also other species of *Leishmania* may reach Italy finding a phlebotome species capable to establish a local cycle spreading the parasite. Today, we "only" know that cases of foreigners affected by exotic *Leishmania* species have already been reported: not only the above mentioned *L. tropica* but also *L. major* from Africa and Middle East, and *L. braziliensis* e *L. panamenisis* from South America. Unfortunately, neither the clinical observation of the patient nor the morphological observation of the parasite under a microscope allow to identify the *Leishmania* species, thus increasing the above mentioned risks since an exotic *Leishmania* might be at first mistaken with the local *L. infantum* and a correct identification might take place much later, when the exotic parasite has already spread.

To conclude, it is necessary to keep on monitoring and investigating to complete the picture of the distribution and bio-ecology of the *Phlebotomus* species, especially *P. sergenti*, and ensure that *L. tropica*, as well as any other exotic *Leishmania*, has not already started to set itself up in Sicily; in the meantime, it would be much helpful if a better sanitary control of stray dogs and immigrants might be achieved.

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MONOGRAPH

Preliminary observations on the use of drones in the environmental monitoring and in the management of protected areas. The case study of "R.N.O. Vendicari", Syracuse (Italy)

Giorgio Sabella[1]*, Fabio Massimo Viglianisi[1], Sergio Rotondi[1] & Filadelfo Brogna[2]

[1]Department of Biological, Geological and Environmental Science, Section of Animal Biology, University of Catania, via Androne 81, 95124 Catania, Italy; e-mail: sabellag@unict.it; fabiovgl@unict.it; sergiorotondi@hotmail.it
[2]Regional Department of Rural and Territorial Development, Service Office for the Territory of Syracuse, Italy; e-mail: fbrogna@regione.sicilia.it
*Corresponding author

ABSTRACT The possible utilization of UAS (Unmanned Aircraft Systems), also called drones, as means for the environmental monitoring and the management of protected areas has been investigated. The study was carried out in "R.N.O. Vendicari", Syracuse (Sicily, Italy) in relation to the problems of the fruition's management of the protected area. Some operational proposals on the use of drones for these aims are suggested and the preliminary results are presented.

KEY WORDS UAS; Sicily; Protected areas; Environmental monitoring; Management; Drone.

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INTRODUCTION

The study of ecology, especially environmental monitoring, has benefited, since the 60s of last century, of the latest technologies and of the technical innovations openig up new possibilities in many theoretical and applied branches of the natural sciences. Since the 80s of last century, a further contribution to research in this field has been made with the use of two new technologies: the GPS (Global Positioning System) and the GIS (Geographical Information System).

In the last decade even the use of Unmanned Aircraft Systems (UAS) seem to have had the same kind of impact in the scientific and applied areas (Anderson & Gaston, 2013; Chabot & Bird, 2015). The use of drones has strongly increased due to their ease of use and the lowering of the costs of these remotely piloted aircrafts. On board they can, carry small computers, cameras and various sensors. These can be easily used by non-specialists, who can then use them in many work activities to collect data by multiparameter sensors (Thamm & Judex, 2006). In general, the use of these resources has helped in increasing, as never before, the acquisition of both qualitative and quantitative environmental and spatial data (Marris, 2013). Applications to this data can be broadly divided into two categories: research applications and direct conservation applications (Sandbrook, 2015).

Apart from the research applications, also the control of the risk areas or of protected ones, will certainly benefit from the use of these unmanned aircraft systems, supporting operators and ensuring that the management and monitoring of these areas are more reliable convenient and accurate (Krämer

& Thamm, 2006; Kohl & Wich, 2012). This is part of the ongoing relationship between the effort to safeguard protected areas and their fruition (West et al., 2006).

The extension of the R.N.O. "Oasi faunistica di Vendicari" (Southern Eastern Sicily) and its criticality along with the continued reduction of the supervisory staff, make it difficult to continously monitor. The aim of this paper is to determine whether the use of UAS could make the monitoring and the control of this area easier by reducing costs and at the same time ensuring that the interventions of the teams on the ground are more efficient.

In this work we use the word drone or UAS for all types of aircrafts without an on board pilot, although in the literature these vehicles are often classified and designated by various other names (Anderson & Gaston, 2013).

MATERIAL AND METHODS

Study area and management issues

The Oriented Natural Reserve "R.N.O. Oasi faunistica di Vendicari", instituted by D. A. 14 March 1984 in accordance with L. R. 98/81, is located in the southeast of Sicily, between Noto and Pachino in the province of Syracuse, and occupies an area of about 1,517 hectares (Fig. 1). Its perimeter is included in those of the ZPS ITA090029 - Pantani della Sicilia sud-orientale, and of the SIC and ZPS ITA09002 - Vendicari, instituted in accordance with Directive 1992/43/EEC and with Directive 2009/147/EC. The reserve is also included within the area identified by IBA (International Bird Areas) criteria cod. IBA 1998–2000: IT167 "Pantani di Vendicari e di Capo Passero", and in the Ramsar area "3IT043 Vendicari", in accordance with D.P.R. 448 of 13 March 1976, because it is recognized as a key area for the resting and the migration of migratory birds.

The reserve is a coastal area of great natural and landscape value, characterized by high plant and animal biodiversity thanks to the variety of habitats (rocky and sandy coasts, brackish and freshwater swamps, salt marshes, Mediterranean scrub, scrubland and cultivated areas), due to the presence of various types of substrates, as well as edaphic and hydrogeological relationships. This did not prevent

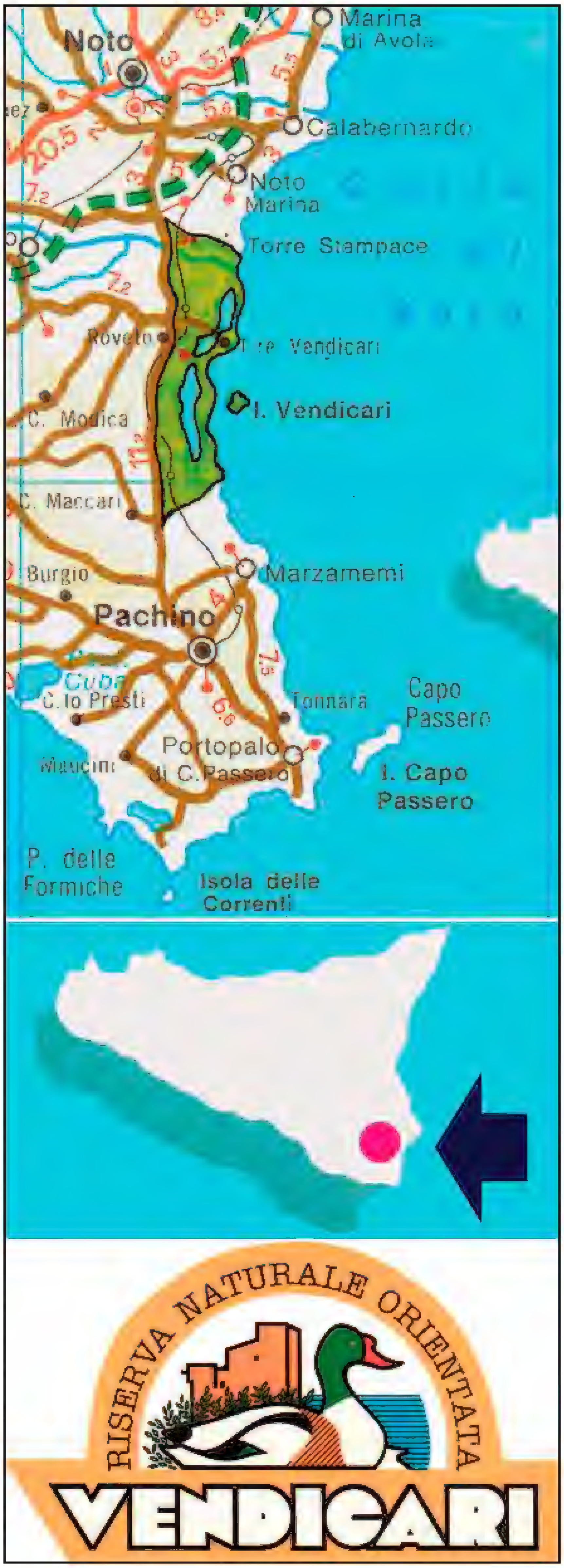

Marina di Avola
Noto
Calabernardo
Noto Marina
Torre Stampace
Roveto
Torre Vendicari
I. Vendicari
C. Modica
C. Maccari
Burgio
Marzamemi
Pachino
Cuba
C. lo Presti
Tonnara
Capo Passero
Portopalo di C.Passero
Maucini
I. Capo Passero
P. delle Formiche
Isola delle Correnti
RISERVA NATURALE ORIENTATA
VENDICARI

Figure 1. Geographical framing, maps and logos of The Oriented Nature Reserve "R.N.O. Faunistic oasis of Vendicari", Syracuse (Sicily, Italy).

about half of the reserve's territory to be used for agricultural activities (AA.VV., 1991).

The overall climate is rather dry, characterized by mild winters with little rainfall and hot, dry summers. Average annual rainfall does not reach 400 mm per year, with a maximum of just over 60 mm in October, December and January, and values close to zero in the summer months (June to August). The average annual temperature is 18.2 °C. The coldest months are January and February with a monthly average of 11.9 °C. Quite high temperatures are reached in July and August with average monthly respectively being 25.3 °C and 26.2 °C (AA.VV., 1991). The reserve falls within the lower dry thermomediterranean bioclimatic belt (Scelsi & Spampinato, 1998).

The management plan of "Pantani della Sicilia sudorientale" (2009), approved under the condition with D.D.G. 673/2009 of Regional Councillorship of Land and Environment, highlights several critical aspects of the R.N.O. mainly related to agricultural activities, but also to the high human pressure linked to its touristic fruition, especially in the summer months; during just 2014 an estimate of, by defect, more than 120,000 visitors visited the beaches of Vendicari (Iuvara, 2015). The damages caused to the protected areas by an excessive fruition have already been studied and documented (Muhar et al., 2002).

Technical characteristics of the utilized materials

The drone used is the Phantom 3 Professional (Fig. 2). The technical characteristics of the drone and its equipment are summarized in Table 1.

Regulatory information on UAS flights

The only current regulation for UAS flights is the Unmanned Aircraft Systems Regulation of ENAC (Civil Aviation Authority) (2nd edition published in 16 July 2015 and updated in 21 December 2015).

There are several types of the UAS and there are different classifications in which they are grouped per weight, range, use, etc. (see Anderson & Gaston, 2013 for a review). Among the different UAS types, the two most common are those weighing less than 300 grams and 2 kg. The lightest models (weighing less than 300 g) are characterized by low flight range (under 10 minutes) combined with lower quality of photographs. For this reason we have chosen to operate the flights using a drone belonging to the second category (whose operations are regulated by art. 12 of ENAC Regulation): the model Phantom 3 Pro. This has an upper flight range of up to 20 minutes and is equipped with a camera with 4k resolution, which has a high level of image definition. These characteristics make it appropriate for the purposes of the present study.

Figure 2. The Phantom 3 Professional built by DJI.

For whichever flight scenario, it is mandatory that the driver is recognized by ENAC (art. 21) through the adequate certification. The drone must also be insured.

Based on the experience and on the fact that the ENAC regulations are constantly evolving and clear guidelines have yet to be enacted, we propose the following methodological process consisting of a series of good practices to be followed in the case of any flight plan processing:

Download from the Aviation website (www.aeronautica.difesa.it) the updated version of the Italian Aviation Map (CAI) in which the obstacles to the flight and the zone types to air controlled traffic (VFR Visual Flight Rules) are shown.

Identify the flight area and take action based on the type of the overfly zone. The prohibited airspaces, according to paragraph 4 of the article 24 of the ENAC Regulation, are those within the ATZ (Aerodrome Traffic Zone) of an airport, or located at a distance of less than 5 km from an airport and those within the active regulated areas and the prohibited areas. In the latter all protected areas are included and so it is to necessary to request the prior authorization of the Managing Authority. When obtained this authorization must also be requested from the ENAC Authority (article 24, paragraph 6 of ENAC Regulation).

The visual flight (Visual Line of Sight or VLOS) must always be performed by a pilot with Attestation of Pilot of UAS (article 21, paragraph 1 of ENAC Regulation) and with a medical certification of class II issued by the standards relating to the license LAPL (Light Aircraft Pilots Licence) (article 21, paragraph 2 of ENAC Regulation). The pilot must be accompanied by a qualified observer (article 5 of ENAC Regulation).

Aircraft: technical specification	
Weight (including battery and propellers	1280 g
Diagonal size (including propellers)	590 mm
Max Ascent Speed	5 m/s
Max Descent Speed	3 m/s
Hover Accuracy	Vertical: +/- 0.1 m (when Vision Positioning is active) or +/- 0.5 m; Horizontal: +/- 1.5 m
Max Speed	16 m/s (ATTI mode, no wind)
Max Service Ceiling Above Sea Level	6000 m (Default altitude limit: 120 m above takeoff point)
Operating Temperature	0°C to 40°C
GPS Mode	GPS/GLONASS
Camera: technical specification	
Sensor	Sony EXMOR 1/2.3” Effective pixels: 12.4 M (total pixels: 12.76M)
Lens	FOV 94° 20 mm (35 mm format equivalent) f/2.8, focus at 8
ISO Range	100-3200 (video) 100-1600 (photo)
Shutter Speed	8s -1/8000s
Image Max Size	4000 x 3000
Still Photography Modes	Single Shot; Burst Shooting: 3/5/7 shots; Auto Exposure Bracketing (AEB): 3/5; Bracketed Frames at 0.7EV Bias; Time-lapse.
Video Recording Modes	UHD: 4096x2160p 24/25, 3840x2160p 24/25/30; FHD: 1920x1080p 24/25/30/48/50/60; HD: 1280x720p 24/25/30/48/50/60;2.7K: 2704 x1520p 24/25/30 (29.97)
Remote Controller and APP: technical specification	
Operating Frequency	2.400 GHz-2.483 GHz
Max Distance	Up to 5 km or 3.1 miles (unobstructed, free of interference)
Mobile App	DJI GO
Latency	220ms (depending on conditions and mobile device)
Required Operating Systems	iOS 8.0 or later; Android 4.1.2 or later

Table 1. Technical specification of: Aircarft, Camera and Remote controller of Drone used.

Perform a pre-flight checklist, which includes: checking weather and of environmental conditions; evaluting flight risks (obstacles, buildings, towers, high tension cables, etc.); checking of integrity and efficiency of the drone.

Informations on operated flights

The flights are performed according to the requirements of the ENAC Regulation respecting the condition laid down for flight in VLOS, according to article 24, paragraph 2 (maximum height 150 m and ray of maximum distance from operator of 500 m) and also according to article 27 paragraph 2 (Horizontal safety distance of at least 150 m from the groups of people, and at least 50 m from individuals).

The experience was carried out during the first decade of August 2015, from 10.00 to 11.00 a. m., the climatic and weather conditions optimal, wind speeds below 10 kph, temperature 31 °C, Magnetic Storm 3Kp.

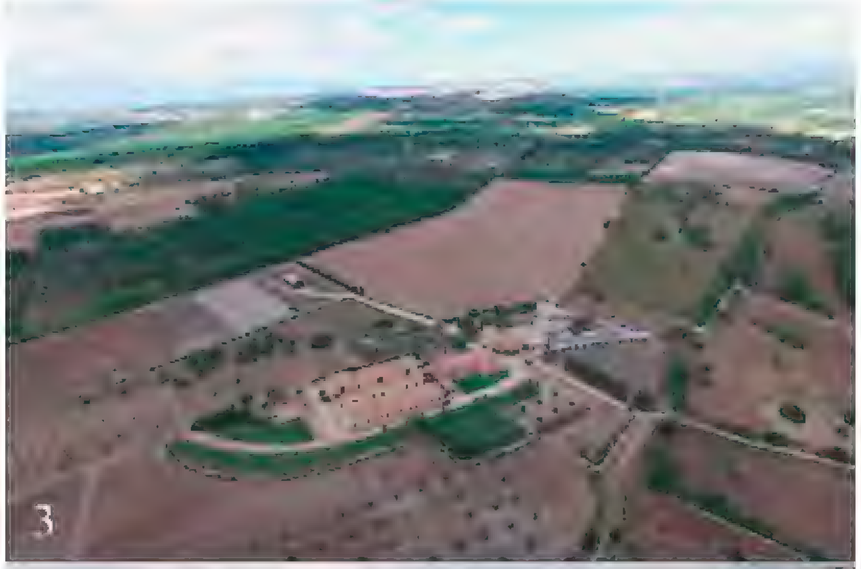
Using as a starting point the Marianelli houses of the Regional Azienda of the State Forests (Fig. 3), which is located roughly in the centre of the reserve, two flight plans were scheduled.

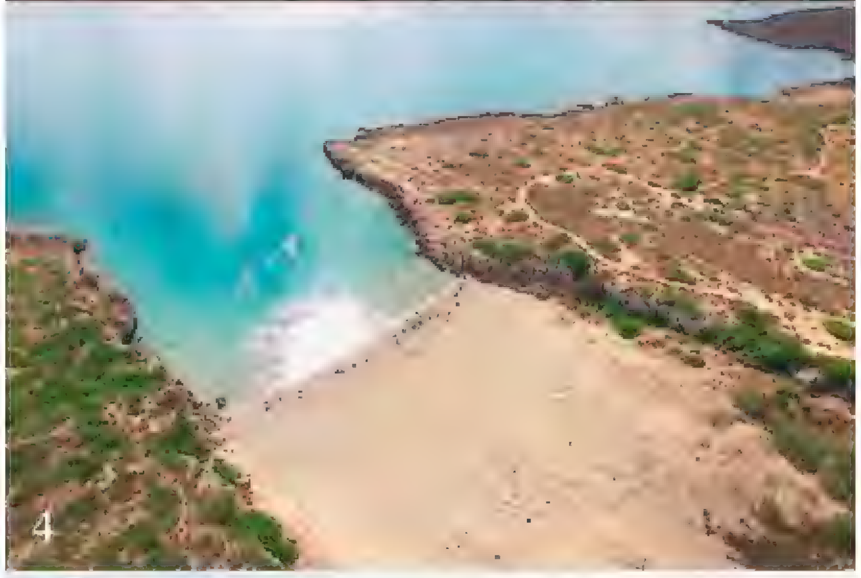
The two flights were scheduled for control of the north side and the south side of the reserve and for the overfly of some fixed points allowing to monitor the access roads and check for unauthorized access to the reserve beaches. Moreover, it was possible to verify the number of bathers and monitor any behaviour prohibited by the Regulation of the reserve in the Calamosche (Fig. 4) and Eloro beaches (Fig. 5).

Operatively, in the two flights the drone remained at a maximum height of 70 m and at a 150 m distance from people for privacy and security reasons.

The first flight (Fig. 6) flew over the south and the southeast zones of the reserve and lasted about 18 minutes, covering a linear path of approximately 4,600 m. with relative displacement of the operator to ensure that the aircraft was always.

During the overflight of the zones, live video and photos were taken. The images were seen by the reserve supervisory staff and then the filming were also observed offline and subjected to analysis and processing by the reserve managers. Particular attention was paid to the overflights of Calamosche beach due to the strong inflow of swimmers at this time. A first live estimate of presence of people on the beach was made and later, in offline mode, an accurate count of the number of swimmers was done. These two numbers were compared with the number of appearances detected by supervisory staff based on daily records of access to reserve. This made it possible to verify the percentage of users who had used the not controlled accesses of the reserve.





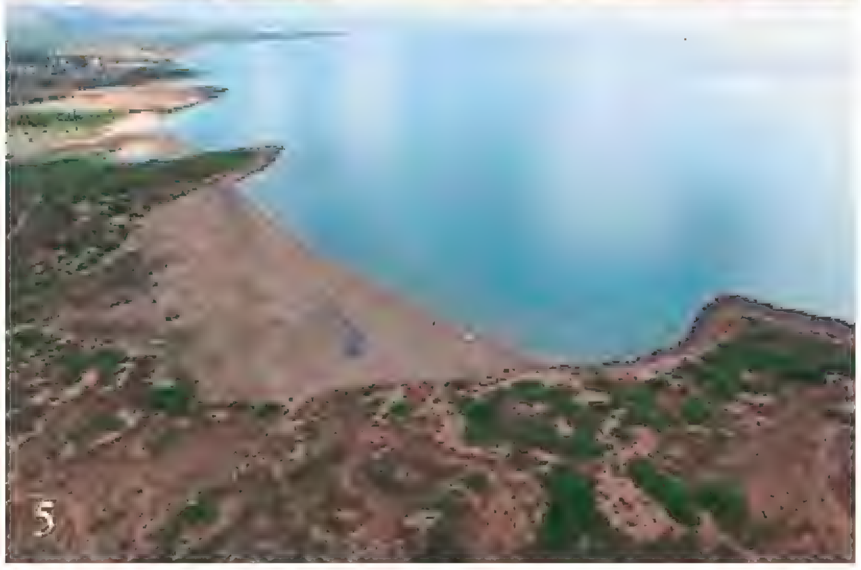


Figure 3. The starting field of the drone, the Marianelli houses of the Regional Azienda of the State Forests photographed by drone.

Figure 4. The Calamosche beach photographed by drone.

Figure 5. The Eloro beach photographed by drone.

The second flight (Fig. 7) flew over the north and northeast zones of the reserve and lasted about 19 minutes, covering a linear path of approximately 3,640 m.

The flight arrangements were the same used in the previous flight. This time, however, in addition to verifying and counting the number of bathers on the beaches of the northern side of the reserve, the position of the parked cars along the access road to the beach was also detected to verify possible grounds for refusal to circulation of any rescue vehicles.

In addition, the flight was scheduled to overfly the houses subject to legal seizure to check the possible construction of new buildings or extensions to existing ones.

RESULTS

The use of the drone inside the R.N.O. Vendicari has been very satisfactory. From a technical point of view, it has been appreciated the extreme ease and immediacy of the procedures of setup and starting (Watts et al., 2010). In fact, the positioning of the batteries on the drone is as simple as changing the battery on a mobile phone, to start the program on the Control Pad less than five minutes are needed, this perspective is a positive factor because the operativity of the drone is virtually immediate and therefore also in emergency circumstances its use would be valid.

Another positive factor has been the battery life of the drone that has allowed about 20–25 minutes of flight and operation in total autonomy and no maintenance, allowing a very thorough reconnaissance of the areas of the reserves examined.

It allows for high quality shooting of video and photographs allowing it to reach a level of detail in the images which was more than satisfactory. Also the streaming link between operator and drone is never lost even when up to several hundreds of meters away, similary the flight controls sent interactively by the operator of the drone were executed without delays.

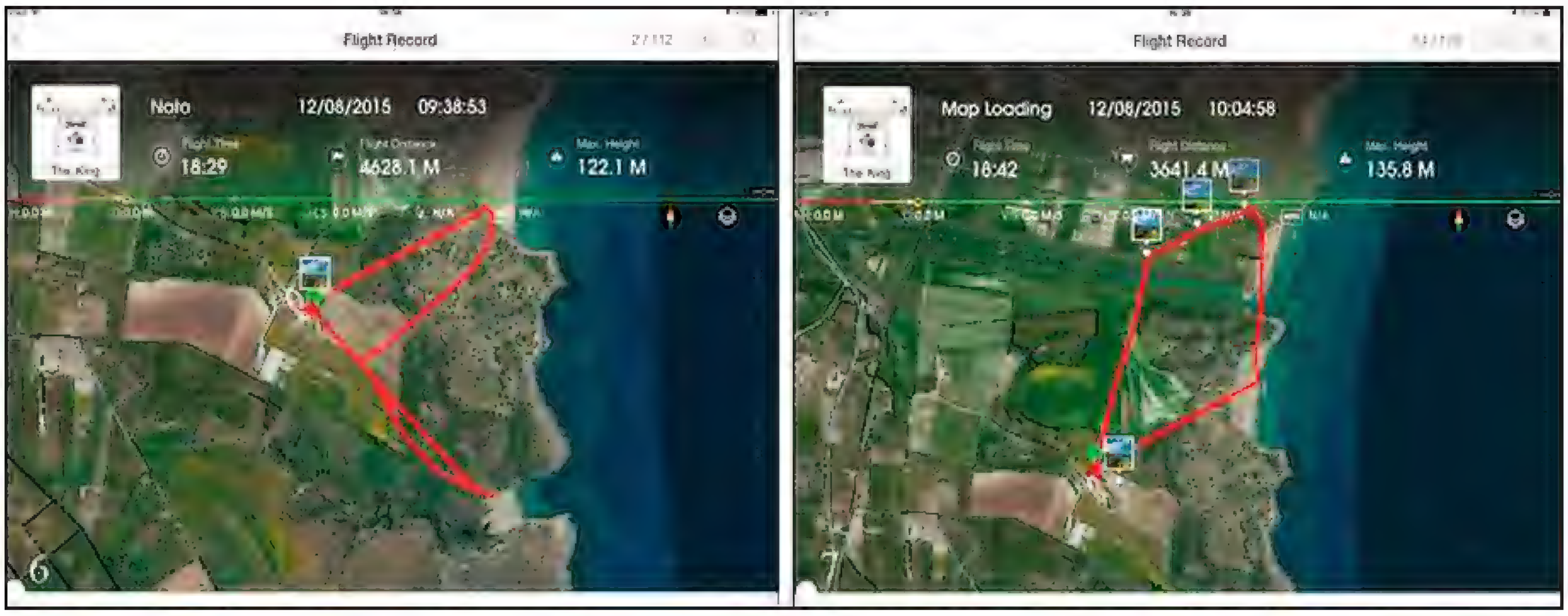
Interesting was also the simulation carried out deliberately to lose contact between the drone and the operator. In this case the software implemented in the aircraft enabled it to return to land independently and at the same starting point. This proves that, even in difficult situations such as problems caused by the weather or by the operator, the drone would not be lost and there would be no accidents on landing, thanks to its excellent emergency system.

On the contrary, there are some ethical and technical disadvantages in the use of the drone. The ethical and social implications (safety, privacy, psychological wellbeing, data security and understanding of conservation problems) in the use of the drones are recently examined by Sandbrook (2015). In particular, with regards to privacy, the main problem is whether it is ethical to monitor people without their knowledge, because this practice could represent an infringement of human rights (see Finn & Wrigth, 2012 for a detailed analysis), although these aspects of privacy have been already invaded with the use of satellite monitoring and fixed cameras. In the case of protected areas, this practice has the deliberate intention of law enforcement and it should be incorporated, with full reason and legality, into the reserve regulation, but on public land it shows some illegality profiles (Sandbrook, 2015). Even the question of confidentiality of data is relevant and needs for regulation.

The risks of misuse of drone technology for the surveillance have been already highlighted and some solutions have been proposed to avoid conflicts with local people (West et al., 2006; Paneque-Galvez et al., 2014). The main recommended solutions are transparency of information and the adoption of communally-agreed rules. The use of fear as a tool of conservation raises obvious ethical questions (Sandbrook, 2015).

Also like all electronic devices even UAS are exposed to hacker risk, which would allow an attacker to take control of the aircraft by changing course with possible serious consequences (Hartmann & Steup, 2013).

As regards the technical problems, the main one is detected in the operating limits of the batteries of the drone that do not allow their use with temperatures above 40 °C. During the performed flights, the weather conditions and the time (early morning between 10.00 and 11.00 a. m.) fell extensively in the tolerance range of the batteries, while in the same location, in the following weeks and in the first hours of the afternoon, the temperature had reached the tolerance limit of the instrument and therefore no flight could not have been carried out.


Flight Record

Noto 12/08/2015 09:38:53

18:29

4628.1 M

122.1 M

Flight Record

Map Loading 12/08/2015 10:04:58

18:42

3641.4 M

135.8 M

Figure 6. Flight plan number 1, with full telemetry, itinerary direction of Calamosche beach. The red line indicate the path of drone. Figure 7. Flight plan number 1, with full telemetry, itinerary direction of Eloro beach. The red line indicate the path of drone.

This is a significant problem because it does not allow monitoring of users of the reserve in the period that is experiencing the greatest influx of visitors.

CONCLUSIONS

Although the use of drones for conservation is in its infancy and there is currently limited evidence regarding their effectiveness as a conservation tool (Sandbrook, 2015), in our case study the use of unmanned aircrafts has proved a very useful tool for the reserve operators for the ease of use of the drone and for the results obtained from the flights.

In addition, his low cost could favourably influence the choice by the administration in the purchase and use of this instrument, which could validly help the reduced number of supervisory staff of the reserve in the surveillance action. Moreover, the possibility to program the flights on predetermined paths and at set intervals during the day represents a further advantage linked to the use of drones for the monitoring of protected areas.

In any case, the drone could not be used as a substitute for the control actions and for intervention of operators but should be used only as a support means for operator on site, who could be relieved from unnecessary patrols and would thus be able to intervene more timely and precisely in places where the aerial monitoring would show violations, misconduct, etc.

Also valuable would be its contribution to the prevention and deterrence of the fires and of the harmful actions. In fact, the overflight at low altitude is immediately noticed, and induces in people a more cautious and respectful attitude because the drone allows, thanks to high image quality, the precise recognition of people and/or vehicles who are offenders of the reserve regulation. This last point regards the regulatory and ethical aspects is one on which we must reflect carefully (particularly as it regards the privacy and confidentiality of the data) and probably it will be necessary to operate changes of the laws, rules and regulations regarding the use of drones in the monitoring and control of protected areas. For example, given that the ENAC Regulation is still being defined and applied throughout the national territory, it would be desirable that it is update to provide different rules for overflights of natural areas and reserves, since most are sparsely populated. This would help reduce some constraints and thus allowing to increase productive use of drones for the environmental monitoring (Rango & Laliberte, 2010). But all this should not discourage the researchers to try and use this new technology and assess the benefits that this can bring especially in the field of environmental protection.

ACKNOWLEDGMENTS

A heartfelt thanks to friends prof. David Mifsud and dr. Simone Cutajar of Malta University for careful and punctual review of the English language.

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Biodiversity Journal, 2017, 8 (1): 87–104 **MONOGRAPH**

The wild vascular flora of the Archaeological Park of Neapolis in Syracuse and surrounding areas (Sicily, Italy)

Pietro Minissale[1] & Saverio Sciandrello[2]

[1]Department of Biological, Geological and Environmental Science, Section of Animal Biology, University of Catania, Italy
[1, 2] C.U.T.G.A.N.A. Centro Universitario per la Tutela e la Gestione degli Ambienti Naturali e degli Agroecosistemi Università di Catania, Italy

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ABSTRACT

This paper presents an updated list of the wild vascular flora growing in the Archaeological Park of Syracuse and surrounding areas. The list of plants is the result of a bibliographic analysis and field surveys carried out in 2013–2015. A total of 343 specific and infraspecific taxa are reported. The families most represented are Poaceae (43), Fabaceae (38) and Asteraceae (35 taxa). The analysis of the biological spectrum of the vascular flora indicate the predominance of therophytes (51%) and hemicryptophytes (20%) while, from a chorological point of view, most of the species show a Mediterranean distribution (134 taxa). The phytogeographical value of some rare species, in particular *Origanum onites*, *Elatine gussonei*, *Callitriche truncata*, *Aristolochia altissima* and *Brassica souliei* subsp. *amplexicaulis* is discussed. The presence of some alien species, such as *Vachellia karroo*, *Lantana camara*, *Ailanthus altissima* is also highlighted, because in this area they represent a serious threat to native plant biodiversity.

KEY WORDS *Origanum onites*; *Elatine gussonei*; Habitats of Community interest; conservation; alien species.

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INTRODUCTION

The Archaeological Park of Syracuse, famous for the big Greek Theater and other vestiges of Greek and Roman times, houses elements of flora and vegetation of great natural value which are maintained over time thanks to the protection of the archaeological site itself. This constraint prevents very common activities on the outside areas such as grazing, fire and urbanization. In this way the protection and conservation of species and plant communities of great importance, indicators of special microhabitats were indirectly guaranteed. In 2013 the execution of major maintenance of the inside public green, made by the Forestry of Syracuse, following the provisions of the Superintendence, gave the opportunity to carry out a study on the flora aimed at its protection during worksite activities. In this way it was possible to update the knowledge on the vascular flora and to highlight some emergencies and peculiarities so far not fully known, which make even more extraordinary the cultural and natural value of the area. The research has taken account of earlier studies. In particular is worthy of mention the floristic research of Zodda (1928, 1929), who recorded many species for the archaeological site in question within a study on the flora of the municipality of Syracuse. More recently, studies on the flora and vegetation of the archaeological areas of Syracuse were made by Corbetta et al. (2002), on the Greek Theatre and the surrounding areas; by Salmeri & Guglielmo (2012) on the Latomie of Syracuse; Guglielmo et al. (2002) on "Latomia dei Cappuccini"; Guglielmo et al. (2006) on the archaeological sites in eastern Sicily.

MATERIAL AND METHODS

The plants list is the result of a bibliographic analysis and field surveys carried out during the years 2013–2016. The study focused on the census of native vascular flora with particular regard to the species of phytogeographical or natural interest, but also to the naturalized non-native species, potentially invasive and their location on the site; including their GIS mapping.

The nomenclature follows Giardina et al. (2007); relatively to the Orchidaceae the reference was Delforge (2005). Flora of Italy (Pignatti, 1982), Med-Checklist (Greuter et al., 1984, 1986) and Flora Europaea (Tutin et al., 1964–1980) were also consulted.

The collected samples are preserved in the herbarium of the Department of Biological Geological and Environmental Sciences of Catania University (CAT).

Study area

The study area includes the fenced archaeological park, which covers about 23 hectares and the outside area to the west of the park on the southern side of the "Colle Temenite", which is also subjected to archaeological restrictions. Geographically the site falls in the Hyblaean district (Fig.1), a distinct area from the rest of Sicily, both in geological (Manuella et al., 2015) and phytogeographical terms (Brullo et al., 2011). The area is characterized by a Miocene carbonatic series, consisting mainly of calcirudite, belonging to the formation Monti Climiti. The whole area is affected by various forms of surface erosion as alveolar cavities, grooves, and trays of corrosion. Throughout the area tectonic fractures are also present, many of them are perpendicular to the surface and therefore easily accessible for the rainwater that increases their expansion. The area is also affected by forms of underground karstification (Lena, 1990).

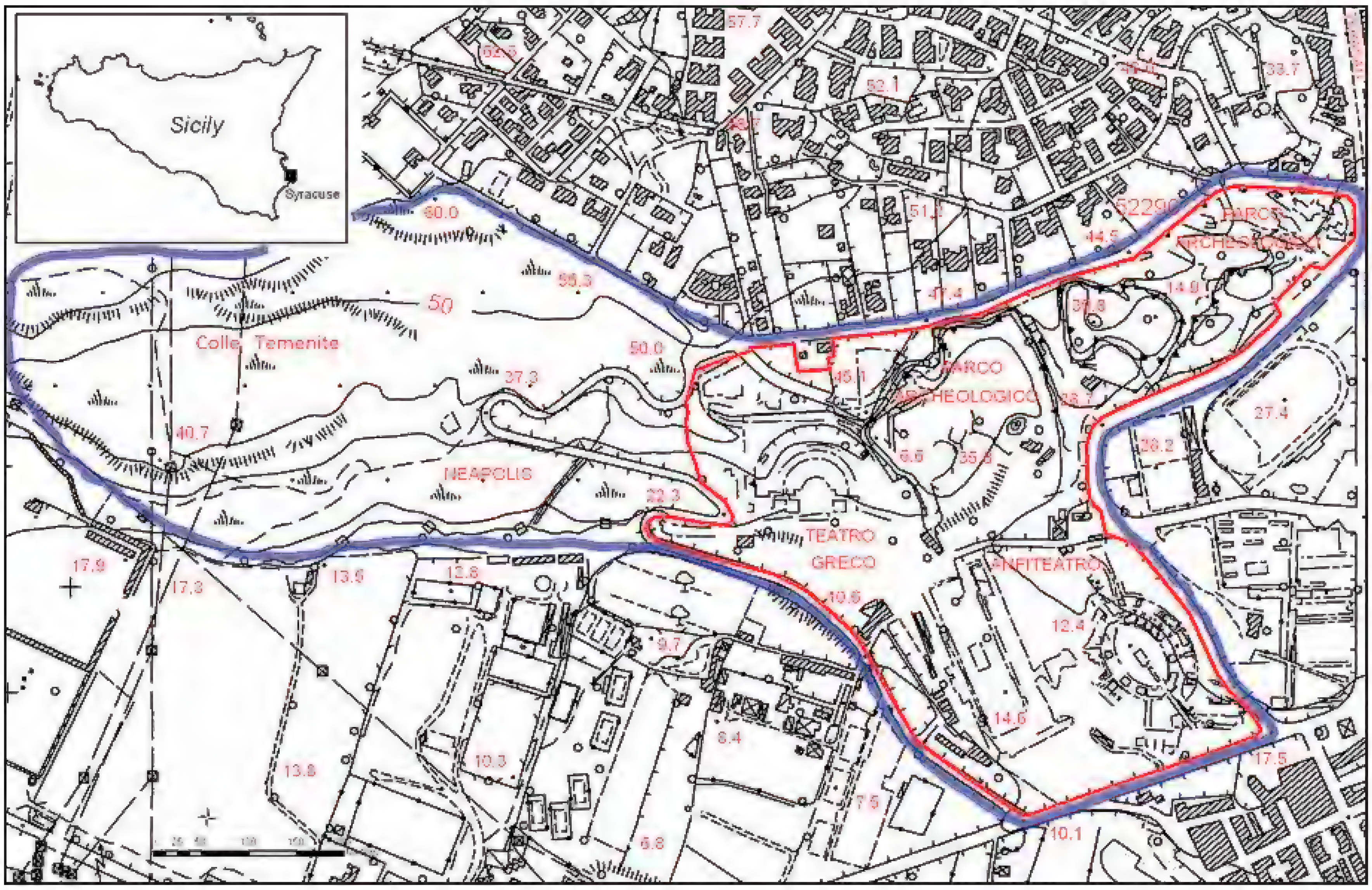


Figure 1. Study area: the Archaeological Park of Syracuse and surrounding areas (Sicily, Italy).

Regarding the climate, the Syracuse thermo-pluviometric station records average annual temperatures of 18.2 ° C and average annual rainfall of 543 mm (Zampino et al., 1997). Overall the bio-climate of the area can be defined lower thermomediterranean, lower dry, according to Rivas-Martinez (1994) and Bazan et al. (2015).

RESULTS AND DISCUSSION

The research allowed to update the list of flora, which has resulted in 343 recorded species, some of them are of great phytogeographical and conservation value. Previously Zodda (1928, 1929) had reported 158 entities, by making collections of flora in the town of Syracuse for the archaeological area and Temenite hill; then Corbetta et al. (2002), for the area of the archaeological park, reported 191 entities, many of which not recorded by Zodda. The current study has led to a considerable increase of the flora's list for the area, also confirming the presence of the rarest species previously reported. Taking account of the limited size of the site, and by the fact that a fairly wide area is used as a garden, the vascular wild flora, overall, is quite rich and diversified. There are also many ornamental species that are not mentioned here with the exception of those showing autonomous capacity to spread. For the ornamental species census, see Salmeri & Guglielmo (2012) and Minissale et al. (2016).

On the whole, the chorological spectrum (Fig. 2) shows the prevalence of species with broad Mediterranean range (134 taxa); some others have a partial Mediterranean range (34), few species have a range which extends in temperate regions (84 taxa) or in tropical/arid areas (43 taxa) or almost all over the world (12 taxa). Important features of this flora are: on the one hand the endemics (9 taxa, Sicilian or S Italy and Sicily endemics), precious elements of this site, and on the other hand the high number of alien naturalized species (27 taxa), that trivializes the flora and might threaten native species. The biological spectrum shows, as expected, the prevalence with over 50% of therophytes followed by hemicryptophytes and geophytes (Fig. 3).

Among the species already known in this area, the presence of *Origanum onites* has a phytogeographic relevance, this species having an east Mediterranean distribution, widespread on Greek and Turkish coasts of the Aegean Sea and in most of the Aegean islands (Vokou et al., 1988; Aykut Tonk et al. 2010). It is also present in Sicily only near Syracuse (Fig. 4) and reported in Malta (Greuter et al., 1986), but no longer found because probably only cultivated (Mifsud, 2007). It is to remark that the species was described by Linnaeus (1753) from a herbarium specimen just collected from Syracuse (Fig. 5). Before Linnaeus, Boccone (1697) had already shown this species to Syracuse, identified, as was the custom at that time, with a diagnostic phrase "Origanum *lignosum Syracusanum, perenne umbella amplissima, brevi lato, nervoso folio, nigricante*". He pointed out that it grew in Sicily only at Syracuse, on the road for Melilli, about two miles from the town, that is in

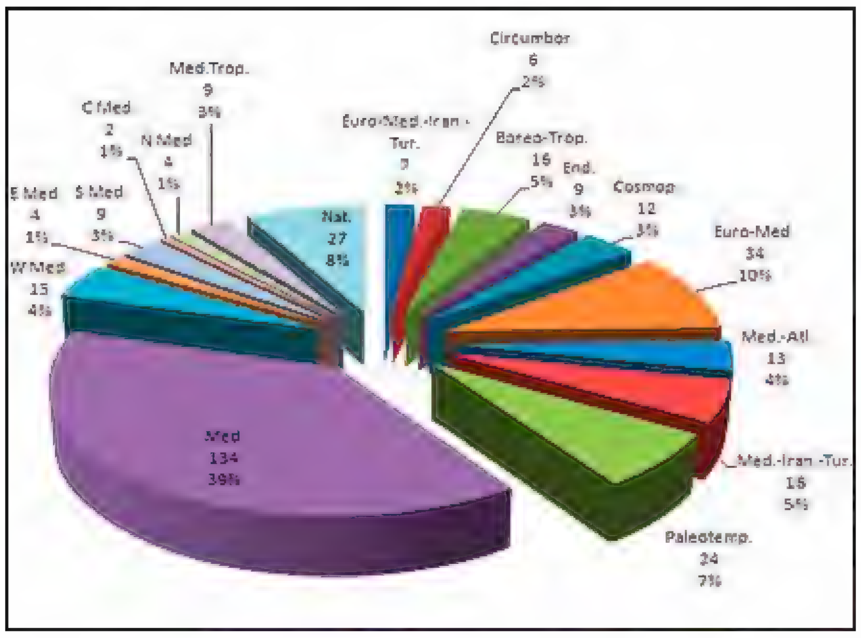


Figure 2. Chorological spectrum (see text).

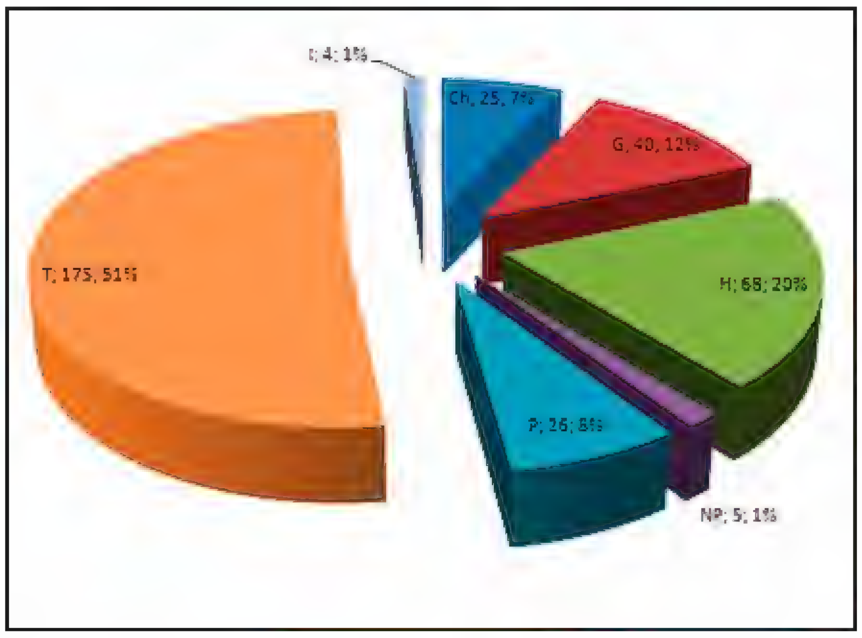
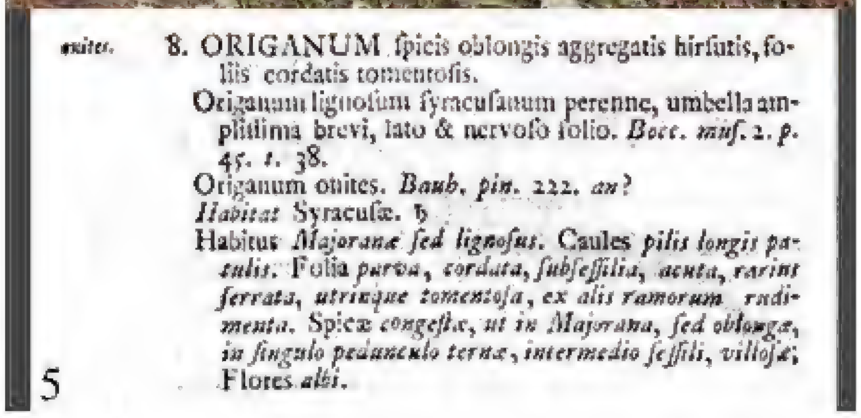


Figure 3. Biological spectrum (see text).



onites. 8. ORIGANUM ſpicis oblongis aggregatis hirſutis, foliis cordatis tomentoſis.
Origanum lignoſum ſyracuſanum perenne, umbella ampliſſima brevi, lato & nervoſo folio. *Bocc. muſ. 2. p. 45. t. 38.*
Origanum onites. *Bauh. pin. 222. an?*
Habitat Syracuſæ. ♄
Habitus *Majoranæ ſed lignoſus.* Caules *pilis longis patulis.* Folia *parva, cordata, ſubſeſſilia, acuta, rarius ſerrata, utrinque tomentoſa, ex alis ramorum rudimenta.* Spicæ *congeſtæ, ut in Majorana, ſed oblongæ, in ſingulo pedunculo ternæ, intermedio ſeſſili, villoſæ;* Flores *albi.*

Figure 4. *Origanum onites*: Siracusa May 30, 2013. Figure 5. *Origanum onites* diagnosis in Linnaeus (1753, 2: 590).

the same places where it is found today. He also compares it with a plant represented by Alpini (1592), called *Hyssopus graecorum*, while Anguillara (1561) describes a hyssop of the Greeks that would be nothing but an oregano that grows in the Cyclades and Crete. On this basis Boccone rightly thought that these entities were the same species and highlights in this way its east Mediterranean range, with a disjunction in Syracuse.

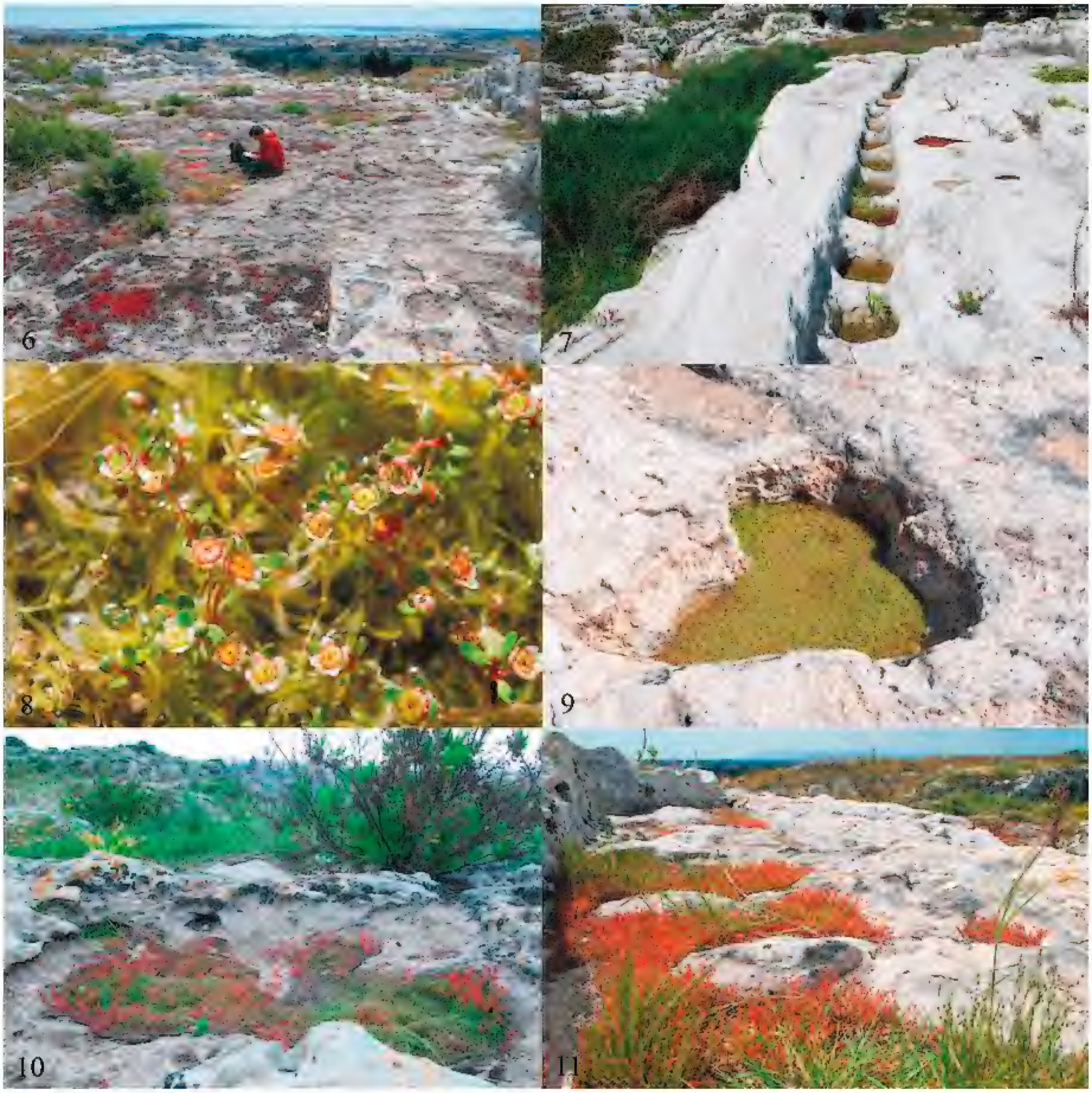
In the archaeological site, where in more recent times was signaled by Zodda (1928), it is found mainly on the rock edges overlooking the “Latomia del Paradiso” and “Intagliatella” and on rocky outcrops of “Colle Temenite”, external to the archaeological park, up to the slope, above the cemetery of Syracuse. Other locations near Syracuse, where the species was reported from Fagotto & Longhitano (1989) are Acradina, “Latomia dei Cappuccini”, Santa Panagia tuna fishery and “Contrada Pantanelli”. The species, from the investigations carried out in the course of this study, is still present in these locations, only Pantanelli has not been confirmed; in any case the most substantial population, formed from some hundreds of individuals remains that of Colle Temenite including archaeological park. This species seems well integrated in the natural vegetation and therefore could be considered a spontaneous species with disjoined areal confined in Sicily, in Syracuse surroundings. However you could not exclude an ancient introduction by the Greeks themselves at the time of the Syracuse foundation in the eighth century BC, or in the following centuries.

Another species of phytogeographical interest is *Brassica souliei* (Batt.) Batt. with the subsp. *amplexicaulis* (Desf.) Greuter et Burdet distributed in Morocco and Sicily (Greuter et al., 1984). In the island is quite common on clay gullies of the central area (Giardina et al., 2007; Brullo et al., 2011), but rare or absent elsewhere. In Syracuse it has already been reported by Pignatti (1982). Since in the rest of Hyblaean district it is not reported, the presence in the archaeological area of the Temenite hill could be traced back, but as accidental introduction, due to intensive exchanges, in the Greek era, with the city of Gela which was connected with Syracuse by a specific road (Burgio, 2005).

The research also helped to highlight an extraordinary, hitherto little known, peculiarity of the archaeological area that significantly enhances the floristic value of this area. The hard Miocenic limestones subjected to natural erosion have dimples and natural excavations where in winter accumulates rainwater that drains into the spring. These dimples in the archaeological area were created in great numbers and in more regular form also by ancient Greek colonists that used to carve rock blocks of various sizes, sometimes leaving cavities and shallow dimples (Mastelloni, 2014). Thus a somewhat peculiar system of temporary pools, for the flora which grows there, originated (Figs. 6, 7).

The most important species found in the pools is *Elatine gussonei* (Fig. 8), so far known only for the Maltese Islands and Lampedusa. Only recently it has been reported to some localities of the southern Hyblaean Mounts (Molnar et al., 2014) and Minissale & Sciandrello (2016) report it for the Neapolis of Syracuse especially in the rock pools around the Tomb of Archimedes (Fig. 9), above the Greek Theatre, but also in outdoor areas on rocky outcrops crossed by the panoramic road near the west side of the archaeological park (Fig.10). In the past it has been confused with the related *Elatine macropoda* Guss.; under this name it has been reported for the archaeological area of

Syracuse by Nicotra (1890) and since then it was no longer observed. In addition Minissale & Sciandrello (2016) showed that the samples collected in some locations in western Sicily can be referred to this species thus becoming a Sicilian-Maltese endemic. The discovery in the archaeological site is of exceptional value considering that just the monuments protection has indirectly favored its survival by preventing activities such as fire, grazing and especially the urbanization that has been rampant over most of the areas bordering the archaeological site. The investigation however, allowed to find *Elatine gussonei* in other places of the outskirts of Syracuse; this is particularly the crags of Akradina and near the old tuna fishery of Santa Panagia.

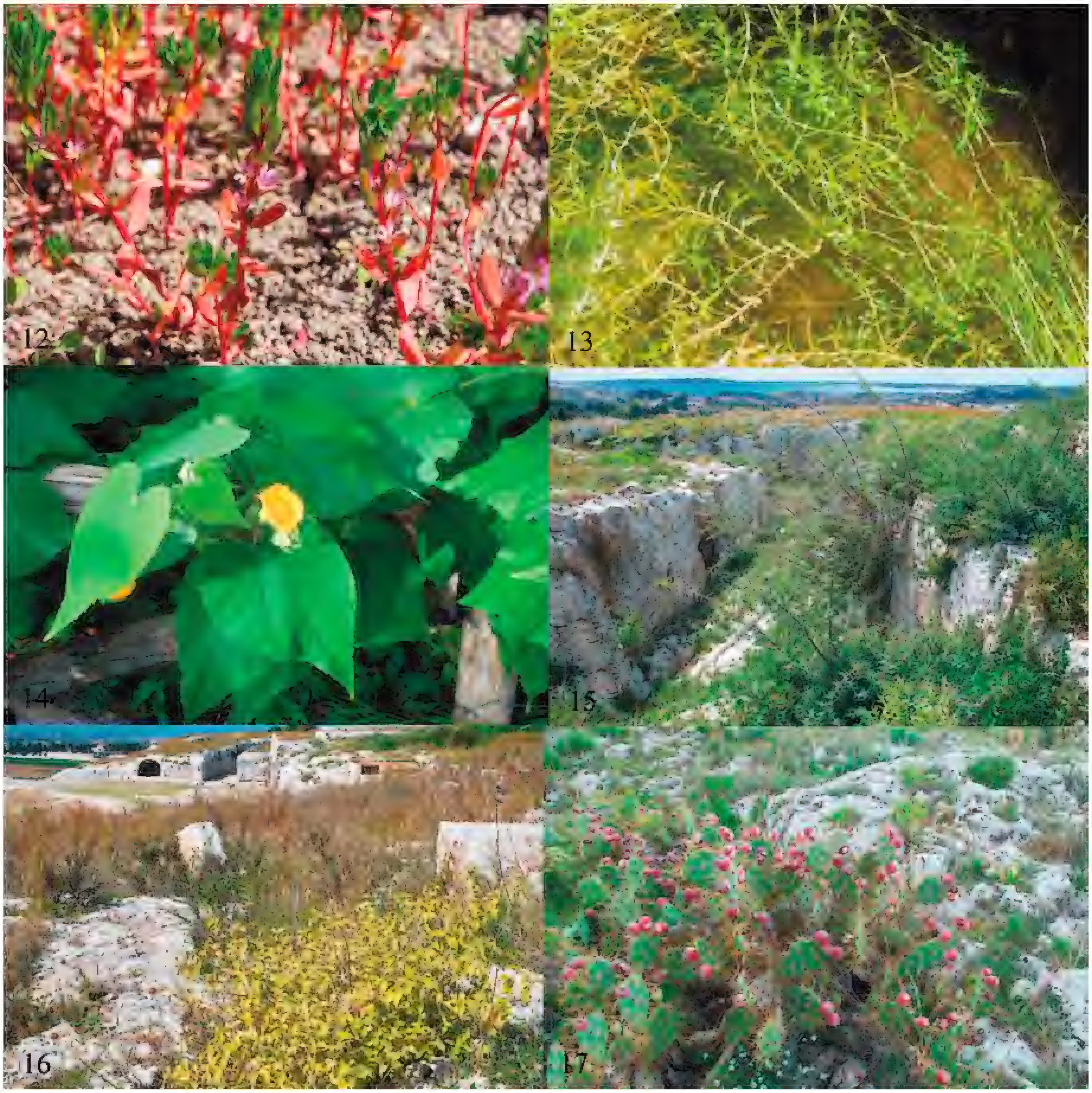


Figures 6–11 Species and plant communities in the archaeological park. Fig. 6: Rock pools and excavations near the Greek Theatre (March 26, 2013). Fig. 7: Grooves and dimples at the Tomb of Archimedes (April 4 2013). Fig. 8: *Elatine gussonei*, detail of flowers and capsules (April 4, 2013). Fig. 9: *Elatine gussonei* community in a small pool at the Tomb of Archimedes (April 4, 2013). Fig. 10: A pool temporary already dry in early spring on the Temenite hill: *Elatine gussonei* vegetation bordered by *Tillaea vaillantii* vegetation (March 26, 2013). Fig. 11: *Tillaea vaillantii* near the Greek Theatre (March 26, 2013).

Other hygrophilous species of considerable rarity found here are *Tillaea vaillantii*, (Fig. 11), *Lythrum hyssopifolia* (Fig. 12), *Callitriche truncata* (Fig. 13).

Each of these hygrophilous ephemeral species characterizes different, typical of temporary pools, plant micro-communities, but each one diversified for flooding period and soil depth (Minissale & Sciandrello, 2016).

In the wide areas of the archaeological park affected by reforestation of pines and eucalyptus trees, flora does not present normally peculiarities of remark, but sometimes species of some interest may be found, as *Aristolochia altissima*, subendemic species of Hyblean Mounts and Algeria, found at the altar of Hieron and upstream of the Greek theater, *Oprhys sicula*, near the Roman amphitheater, *Orchis*



Figures 12–17 Plant species at the archaeological park. Fig. 12: *Lythrum hissopifolia* in pools with deep soil above the Greek Theatre (March 26, 2013). Fig. 13: *Callitriche truncata* in the deeper artificial pools near the tomb of Archimedes (April 4, 2013). Fig. 14: *Abutilon theophrasti* in Latomia Santa Venera (December 14, 2015). Fig. 15: *Vachellia karroo* on the walls of the sacred way above the Greek Theatre (March 26, 2013). Fig. 16: *Lantana camara* (March 26, 2013). Fig. 17: *Opuntia dillenii* (March 26, 2013).

papilionacea var. *grandiflora*, in outside areas of the archaeological park. Another species particularly rare in Sicily (Giardina et al., 2007), is *Abutilon theophrasti*, found in Latomia Santa Venera (Fig. 14).

Alongside these floristic findings of great value, the study also highlighted critical issues, such as the presence and sometimes large spread of some invasive alien species which threaten not only local biodiversity but also the monuments themselves. These are *Vachellia karroo*, native to southern Africa, which can settle easily even in small crevices and cracks in the rock and it is present with hundreds of specimens mainly in the upstream portion of the Greek Theatre (Fig. 15) and close to the tomb of Archimedes. In order to preserve the archaeological site is necessary to pursue over time a schedule for the eradication of this alien species from the archaeological site and where possible from neighboring areas. The risk of its settlement throughout the site is far from negligible, because even if cut at the base of the stem, it has great ability to regrowth. Its ability to occupy niches and rocky ravines, in the long run, leads to the fragmentation of the rocks with serious damage to the archaeological site, but also for the flora and the natural habitats present. They require repetitive tasks such as cutting, chemical control, localized to the stumps in order to reduce the risk of contamination to the rest of the flora and fauna.

Other exotic species spread in the area, with independent propagation capacity, are *Lantana camara* (Fig. 16), *Washingtonia robusta*, *Opuntia dillenii* (Fig. 17). Also for these species containment interventions, and, if possible, eradication, prolonged in time, are required.

Inside the quarries, characterized by greater coolness and moisture of the soil, *Ailanthus altissima*, highly invasive species, took great development, so intensive cuts were carried out during the last works in order to keep it under control; but for the future a stronger action needs to be made such as the uprooting and chemical treatment.

The distribution map of the abovementioned "good" and "bad" floristic emergencies, in the study area, is showed in figure 18.

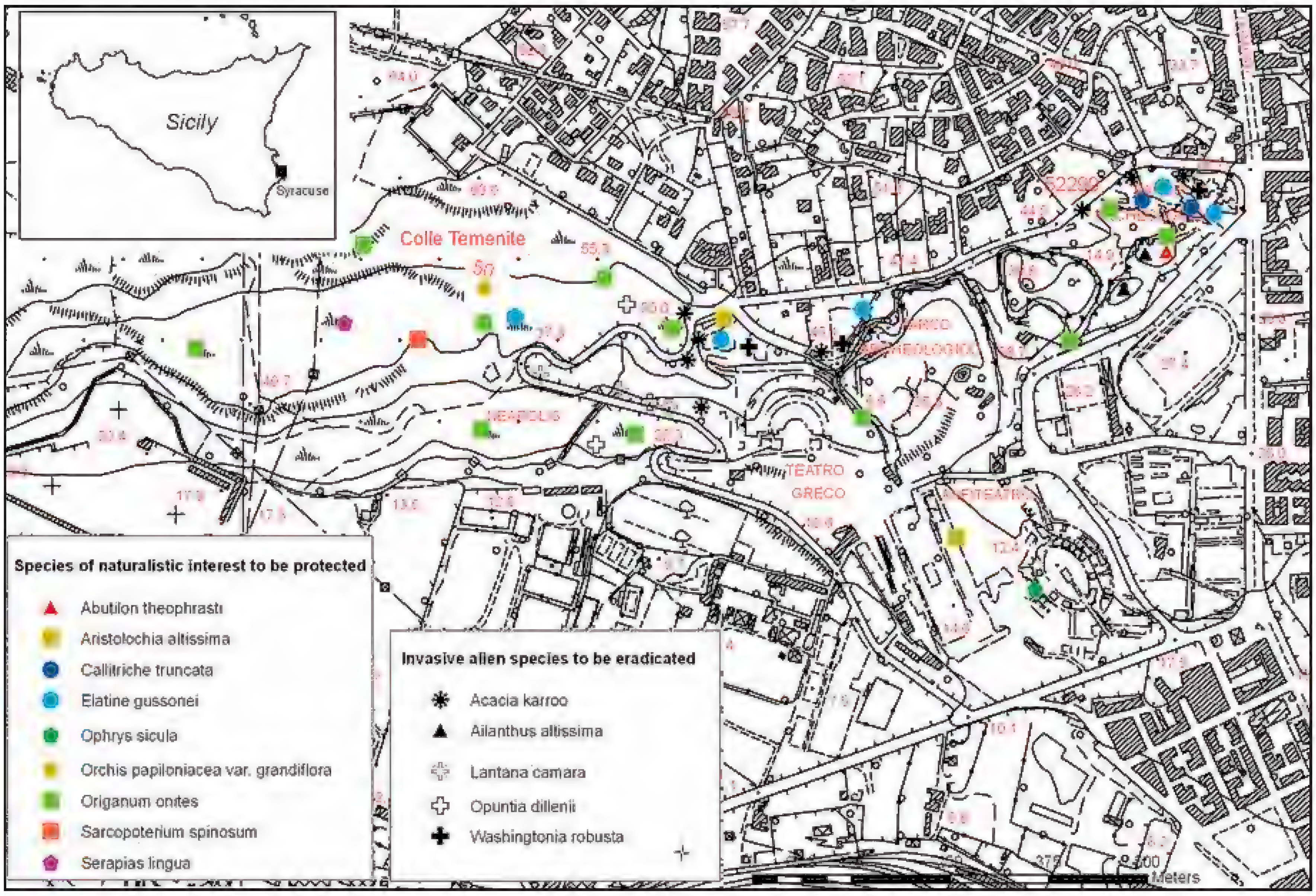

Sicily
Syracuse
Colle Temenite
NEAPOLIS
TEATRO GRECO
ANFITEATRO
PARCO ARCHEOLOGICO
Species of naturalistic interest to be protected
Abutilon theophrasti
Aristolochia altissima
Callitriche truncata
Elatine gussonei
Ophrys sicula
Orchis papilionacea var. grandiflora
Origanum onites
Sarcopoterium spinosum
Serapias lingua
Invasive alien species to be eradicated
Acacia karroo
Ailanthus altissima
Lantana camara
Opuntia dillenii
Washingtonia robusta
Meters

Figure 18. Map of floristic emergencies recorded in the study area: the Archaeological Park of Syracuse and surrounding areas (Sicily, Italy).

FLORISTIC LIST

The following floristic list shows, in addition to the binomial with the author, biological form, chorotype, IUCN category. Abbreviations of life forms follow Pignatti (1982). The following letters indicate the species already reported by Zodda (1928), (Z.a); Zodda (1929), (Z.b); Corbetta et al. (2002), (C.); except where otherwise indicated, they were confirmed as present in the current study; the species of new recording for the site are indicated with the letter (n).

PTERIDOPHYTA
Familia ADIANTACEAE

Adiantum capillus-veneris L.; G rhiz; Boreo-Trop.; (C.)

Familia ASPLENIACEAE

Ceterach officinarum Willd.; H ros; Euro-Med.-Iran.-Tur.; (n)

Familia AZOLLACEAE

Azolla mexicana C. Presl.; I nat; Nat., Trop. America.; (n)

Familia POLYPODIACEAE

Polypodium cambricum L. subsp. *serrulatum* (Arcang.) Pichi Serm.; H ros, Euri-Medit.; (n)

Familia SELAGINELLACEAE

Selaginella denticulata (L.) Spring; Ch rept; Med.; (n)

GYMNOSPERMAE
Familia PINACEAE

Pinus halepensis Miller; P scap; Nat., Med. (extensively planted, occasionally of spontaneous growth); (C.)
Pinus pinea L.; P scap; Nat., Euri-Medit. (planted, occasionally of spontaneous growth); (C.)

ANGIOSPERMAE (Dicotyledones)
Familia ACANTHACEAE

Acanthus mollis L.; H scap; W Med.; (C., Z.a)

Familia AMARANTHACEAE

Amaranthus hybridus L.; T scap; Nat., Trop. America; (C.)
Amaranthus retroflexus L.; T scap; Nat., N America; (C.)
Chenopodium album L.; T scap; Cosmop.; (C.)

Familia ANACARDIACEAE

Pistacia lentiscus L.; P caesp; Med.; (C.)
Pistacia terebinthus L.; P caesp; Med.; (C.)

Familia APIACEAE

Apium nodiflorum (L.) Lag.; H scap; Paleotemp.; (C.)
Daucus carota L. subsp. carota; H bien; Euro-Med.; (C., Z.a)
Foeniculum vulgare subsp. *piperitum* (Ucria) Bég.; H scap.; S Med.; (n)
Smyrnium olusatrum L.; H bien; Med.; (C.)
Thapsia garganica L.; H scap; Med.; (n)
Tordylium apulum L.; T scap; Med.; (Z.a)

Familia APOCYNACEAE

Nerium oleander L.; P caesp; Med.; (C., Z.a)
Vinca major L.; Ch rept; Med.; (Z.b)

Familia ARALIACEAE

Hedera helix L. subsp. *helix*; P lian; Paleotemp.; (C.)

Familia ARISTOLOCHIACEAE

Aristolochia altissima Desf.; P lian; SW Med.; LR; (Z.a)

Familia ASTERACEAE

Anthemis arvensis L. subsp. *arvensis*; T scap; Med.; (n)
Bellis annua L.; T scap; Med.; (n)
Carduus pycnocephalus L.; H bien; Med.; (C.)

Carlina corymbosa L.; H scap; W Med.; (C.)
Chamaeleon gummifer (L.) Cass.; H ros; S Med.; (n)
Calendula arvensis L.; T scap; Euro-Med.-Iran.-Tur.; (n)
Carthamus lanatus L.; T scap; Med.-Iran.-Tur.; (n)
Cichorium pumilum Jacq.; T scap; Med.; (Z.a)
Coleostephus myconis (L.) Rchb. Fil.; T scap; Med.; (n)
Cynara cardunculus L. subsp. *cardunculus*; H scap; Med.; (n)
Glebionis coronarium (L.) Spach.; T scap; Med.; (C., Z.a)
Erigeron bonariensis L.; T scap; Nat., America; (C.)
Erigeron canadensis L.; T scap; Cosmop.; (C.)
Symphyotrichum squamatus (Sprengel) Nesom; H scap; Nat., Trop. America; (C.)
Dittrichia graveolens (L.) Greuter; T scap; Med.; (C.)
Dittrichia viscosa (L.) Greuter; H scap; W Med. (C., Z.a)
Eupatorium cannabinum L.; H scap; Euro-Med.; (C., Z.a)
Filago pyramidata L.; T scap; Euro-Med.; (n)
Galactites elegans (All.) Soldano; H bien; Med.; (C., Z.a)
Helminthotheca echioides (L.) Holub; T scap; Med.; (C., Z.a)
Hyoseris radiata L.; H ros; Med.; (Z.a)
Hypochoeris achyrophorus L.; T scap; Med.; (C.)
Hypochoeris radicata L.; H ros; Med.; (n)
Onopordum illyricum L.; H bien; Med. (Z.a)
Pallenis spinosa (L.) Cass.; T scap; Med.; (Z.a)
Phagnalon rupestre (L.) DC. subsp. rupestre; Ch suffr; W Med.; (n)
Phagnalon saxatile (L.) Cass.; Ch suffr; W Med.; LR; (C., Z.a)
Raphanus raphanistrum L. subsp. *raphanistrum*; T scap; Euro-Med.; (Z.a)
Reichardia picroides (L.) Roth var. *picroides*; H scap; Med.; (C., Z.a)
Senecio vulgaris L.; T scap; Paleotemp.; (C., Z.a)
Silybum marianum (L.) Gaertner; H bien; Med.; (C.)
Sonchus oleraceus L.; T scap; Cosmop.; (C.)
Sonchus tenerrimus L.; H scap; Med.; (C., Z.a)
Tragopogon porrifolius L.; H bien; Med.; (C.)
Urospermum picroides (L.) Schmidt; T scap; Med.; (C., Z.a)
Urospermum dalechampii (L.) Schmidt; H scap; Med.; (Z.a)

Familia BORAGINACEAE

Anchusella cretica (Mill.) Bigazzi, Nardi et Selvi;T scap; E Med.; (Z.a), not found now
Borago officinalis L.; T scap; Med.; (n)
Cerinthe major L. subsp. *major*; G bulb; Med.; (C., Z.a)
Cynoglossum creticum Miller; H bien; Med.-Iran.-Tur.; (C., Z.a)
Echium italicum L. subsp. *siculum* (Lacaita) Greuter et Burdet; (n)
Echium plantagineum L.; T scap; Med.; (C.)
Heliotropium europaeum L.; T scap; Euro-Med.-Iran.-Tur.; (C.)
Myosotis arvensis Hill; T scap; Euro-Med.; (C.)

Familia BRASSICACEAE

Biscutella maritima Ten.; T scap; SW Med.; (Z.a)
Brassica souliei (Batt.) Batt. subsp. *amplexicaulis* (Desf.) Greuter et Burdet; T scap; SW Med.; (reported by Pignatti [1982] in Syracuse); (n)
Capsella bursa-pastoris (L.) Medicus; H bien; Cosmop.; (n)
Coronopus didymus (L.) Sm.; T rept; Nat., N America; (C.)
Diplotaxis erucoides (L.) DC.; T scap; Med.-Iran.-Tur.; (C., Z.a)
Diplotaxis tenuifolia (L.) DC.; H scap; Euro-Med.; (C.)
Erophila verna (L.) Chevall.; T scap; Paleotemp.; (n)
Hirschfeldia incana (L.) Lagrèze-Fossat; H scap; Med.; (n)
Lobularia maritima (L.) Desv.; H scap; Med.; (C., Z.a)
Matthiola incana (L.) R. Br. subsp. *incana*; Ch suffr; NW Med.; (C., Z.a)
Sinapis alba L. subsp. *alba*; T scap; A.; Nat., E Medit.; (C.)
Sisymbrium officinale (L.) Scop.; T scap; Euro-Med.; (C.)

Familia CACTACEAE

Opuntia ficus-indica (L.) Mill.; P succ; Nat., Trop. America; (C.)

Opuntia dillenii (Ker-Gawl.) Haw.; P succ; Nat., Trop. America; (n)

Familia CAMPANULACEAE

Campanula erinus L.; T scap; Med.; (C., Z.a)
Trachelium caeruleum L.; Ch suffr; W Medit.; (Z.b)

Familia CAPPARIDACEAE

Capparis spinosa L.; Ch suffr; Med.-Iran.-Tur.; (C.)

Familia CAPRIFOLIACEAE

Fedia cornucopiae (L.) Gaertner; T scap; Med.; (Z.a)
Sixalis atropurpurea (L.) Greuter et Burdet subsp. *maritima* (L.) Greuter et Burdet; H bien; Med.; (C.).
Valerianella eriocarpa Desv.; T scap; Med.-Atl.; (C.)
Valerianella microcarpa Loisel.; T scap; Med.; (Z.a)

Familia CARYOPHYLLACEAE

Arenaria serpyllifolia L. subsp. *leptoclados* (Reichenb.) Nyman; T scap; Paleotemp.; (C.)
Cerastium glomeratum Thuill.; T scap; Circumbor.; (Z.a)
Minuartia mediterranea (Ledeb.) K. Maly; T scap; Med.; (C., Z.a)
Paronychia argentea Lam.; H caesp; Med.; (Z.a)
Polycarpon tetraphyllum (L.) L.; T scap; Euro-Med.; (C.)
Sagina apetala Ard. subsp. *apetala*; T scap; Paleotemp.; (C., Z.a)
Silene colorata Poiret; T scap; Med.; (Z.a)
Silene gallica L. T scap; Euro-Med.; (n)
Spergularia bocconei (Scheele) Graebner; T scap; Paleotemp.; (C.)
Stellaria media (L.) Vill. subsp. *media*; T rept; Cosmop.; (C.)
Stellaria pallida (Dumort.) Piré; T scap; Euro-Med.; (Z.b)

Familia CONVOLVULACEAE

Calystegia sylvatica (Kit.) Griseb.; H scand; Med.-Iran.-Tur.; (C., Z.a)
Convolvulus althaeoides L.; H scand; Med.; (C., Z.a)
Convolvulus arvensis L.; G rhiz; Paleotemp.; (C., Z.b)
Convolvulus cantabrica L.; H scap; Euro-Med.; (Z.a)

Familia CRASSULACEAE

Sedum caeruleum L.; T scap; S Med.; (Z.a)
Sedum stellatum L.; T scap; Med.; (n)
Tillaea muscosa L.; T scap; Euro-Med.; (n)
Tillaea vaillantii Willd.; T scap; Med.-Trop.; LR; (Z.a)
Umbilicus rupestris (Salisb.) Dandy; G bulb; Med.-Trop.; (n)

Familia ELATINACEAE

Elatine gussonei (Somm.) Brullo, Lanfranco, Pavone et Ronsisvalle; I rad; End. Sicily Maltese Islands; CR; (n, it had been reported by Nicotra (1890), to the Ear of Dionysius, as *Elatine macropoda* Guss.)

Familia EUPHORBIACEAE

Andrachne telephioides L.; Ch suffr; Med.-Iran.-Tur.; LR; (C., Z.a)
Chamaesyce canescens (L.) Prokh.; T rept; Euro-Med.; (C.)
Euphorbia exigua L. var. *exigua*; T scap; Euro-Med. (Z.a)
Euphorbia helioscopia L.; T scap; Paleotemp.; (C., Z.a)
Euphorbia humifusa Willd.; Nat., Asia; (C.)
Euphorbia peplus L.; T scap; Circumbor.; (C., Z.a)
Euphorbia pinea L.; Ch suffr; Med.; (C.)
Euphorbia terracina L.; T scap; Med.; (C., Z.a)
Mercurialis annua L.; T scap; Paleotemp.; (C., Z.a)
Ricinus communis L.; T scap; Nat., Trop. Africa.; (C., Z.a)

Familia FABACEAE

Acacia saligna (Labill.) Wendl. fil.; P scap; Nat., Australia; (n)
Anagyris foetida L.; P caesp; Med.; (n)
Anthyllis vulneraria L. subsp. *maura* (G. Beck) Maire; H scap; W Med.; (n)

Anthyllis vulneraria L. subsp. *rubriflora* (DC.) Arcangeli; H scap; Euro-Med.; (Z.a)

Astragalus boeticus L.; T scap; Med.-Iran.-Tur.; (Z.a)

Astragalus epiglottis L.; T scap; Med.; (Z.a)

Astragalus hamosus L.; T scap; Med.; (C.)

Bituminaria bituminosa (L.) Stirton; H scap; Med.

Hippocrepis multisiliquosa L.; T scap; W Med.

Lathyrus articulatus L.; T scap; Med.; (C., Z.b)

Lathyrus clymenum L.; T scap; Med.; (C.)

Lotus corniculatus L.; H scap; Paleotemp.; (C.)

Lotus cytisoides L.; Ch suffr; Med.; (C., Z.a)

Lotus edulis L.; T scap; Med.; (C., Z.a)

Lotus ornithopodioides L.; T scap; Med.; (C., Z.a)

Medicago italica (Miller) Fiori subsp. *tornata* (L.) Emberger et Maire; T scap; W Med.; (C.)

Medicago littoralis Rohde ex Loisel. var. *littoralis*; T scap; Med.; (Z.a)

Medicago lupulina L.; T scap; Paleotemp.; (C., Z.a)

Medicago minima (L.) Bartal.; T scap; Euro-Med.; (C.)

Medicago polymorpha L.; T scap; Med.-Iran.-Tur.; (C.)

Medicago truncatula Gaertner; T scap; Med.-Atl.; (C.)

Melilotus indicus (L.) All.; T scap; Med.-Iran.-Tur.; (C.)

Melilotus sulcatus Desf.; T scap; Med.; (C.)

Ononis natrix L. subsp. *ramosissima* (Desf.) Batt.; H caesp; Med.; (Z.a)

Ononis reclinata L.; T scap; Med.; (C.)

Ononis viscosa L. subsp. *breviflora* (DC.) Nyman; T scap; Med.; (C.)

Robinia pseudoacacia L.; P caesp; Nat., N America; (Z.b)

Tetragonolobus purpureus Moench; T scap; Med.; (Z.a)

Trifolium campestre Schreber; T scap; Euro-Med.; (C.)

Trifolium nigrescens Viv. subsp. *nigrescens*; T scap; Med.; (C., Z.a)

Trifolium resupinatum L.; T rept; Med.; (n)

Trifolium scabrum L.; T rept; Med.; (C., Z.a)

Trifolium subterraneum L. subsp. *subterraneum*; T rept; Euro-Med.; (n)

Trifolium tomentosum L.; T rept; Med.; (C.)

Tripodion tetraphyllum (L.) Fourr.; T scap; Med.; (C., Z.a)

Vachellia karroo (Hayne) Banfi et Galasso; P caesp; Nat., S Africa; (C. sub *Acacia karroo* Hayne)

Vicia hybrida L.; T scap; Med.; (Z.a)

Vicia sativa L. subsp. *sativa*; T scap; Med.-Iran.-Tur.; (C.)

Familia FAGACEAE

Quercus ilex L.; P scap; Med.; (C.)

Familia GERANIACEAE

Erodium cicutarium (L.) L'Her.; T scap; Paleotemp.; (C.)

Erodium malacoides (L.) L'Her.; T scap; Med.; (C., Z.a)

Erodium moschatum (L.) L'Her.; T scap; Med.; (C., Z.a)

Geranium molle L. subsp. *molle*; T scap; Paleotemp.; (C., Z.a)

Geranium rotundifolium L.; T scap; Euro-Med.; (C., Z.a)

Geranium robertianum L. subsp. *robertianum*; T scap; Circumbor.; (Z.a)

Familia LAMIACEAE

Ajuga chamaepitys (L.) Schreber subsp. *chamaepytis*; T scap; Med.; (C., Z.a)

Ajuga iva (L.) Schreber; Ch suffr; Med.; (C.)

Ballota nigra L. subsp. *uncinata* (Fiori et Béguinot) Patzak; H scap; Euro-Med.; (C.)

Calamintha nepeta (L.) Savi subsp. *nepeta*; H scap; Euro-Med.; (C.)

Coridothymus capitatus (L.) Reichenb. fil.; Ch frut; Med.; (Z.a)

Lamium amplexicaule L.; T scap; Paleotemp.; (C.)

Mentha pulegium L.; H scap; Euro-Med.-Iran.-Tur; (n)

Mentha suaveolens Ehrh. subsp. *suaveolens*; H scap; Euro-Med.; (C.)

Micromeria canescens (Guss.) Bentham; Ch suffr; End. It.-sic.; (Z.a)

Micromeria consentina (Ten.) N. Terracc.; Ch suffr; End. It.-sic.; reported by Zodda (1928), but probably confused with the next species and therefore it could be excluded from this florula

Micromeria graeca (L.) Bentham subsp. *tenuifolia* (Ten.) Nyman; Ch suffr; End. It.-sic.; (n)

Micromeria microphylla (Durv.) Bentham; Ch suffr; End. It.-sic.; LR; (Z.b)

Micromeria nervosa (Desf.) Bentham Ch suffr; Med.; (Z.a)

Origanum onites L.; Ch suffr; E Med.; VU; (C., Z.a)
Prasium majus L.; Ch frut; Med.; (C., Z.a)
Salvia verbenaca L.; H scap; Med.-Atl.; (Z.a)
Sideritis romana L.; T scap; W Med.; (C.)
Teucrium capitatum L.; Ch suffr; Med.; (n)
Teucrium flavum L. subsp. *flavum*; Ch frut; Med.; (C.)
Teucrium fruticans L.; NP; W Med.; (C., Z.a)

Familia LAURACEAE

Laurus nobilis L.; P caesp; Nat., Med.-Atl.; (C.)

Familia LINACEAE

Linum bienne Mill. var. *bienne*; H bien; Med.-Atl.; (Z.a)
Linum strictum L.; T scap; Med.-Iran.-Tur.; (n)

Familia LYTHRACEAE

Lythrum hyssopifolia L.; T scap; Paleotemp.; (n)

Familia MALVACEAE

Abutilon theophrasti Medik. Tscap; Paleotemp.; (n)
Malva nicaeensis All.; T scap; Med.; (Z.a)
Malva parviflora L.; T scap; Med.; (C.)
Malva sylvestris L.; H scap; Euro-Med.; (C., Z.a)

Familia MORACEAE

Ficus carica L.; P scap; N Med.; (C.)

Familia NYCTAGINACEAE

Mirabilis jalapa L.; G bulb; Nat., S America; (C., Z.b)

Familia OLEACEAE

Olea europaea L. subsp. *oleaster* (Hoffmanns et Link) Negodi; P caesp; Med.; (C.)

Familia OROBANCHACEAE

Bellardia trixago (L.) All.; T scap; Med.; (Z.a)
Parentucellia viscosa (L.) Caruel; T scap; Med.-Atl.; (Z.a)

Familia OXALIDACEAE

Oxalis corniculata L.; H rept; Cosmop.; (C., Z.a)
Oxalis pes-caprae L.; G bulb; Nat., S Africa; (C., Z.a)

Familia PAPAVERACEAE

Fumaria bastardii Boreau; T scap; Med.-Atl.; (Z.a)
Fumaria capreolata L.; T scap; Euro-Med.; (C.)
Fumaria flabellata Gasparr.; T scap; Med.; (Z.a)
Fumaria muralis Sonder ex Koch; T scap; Euro-Med.; (Z.a)
Fumaria officinalis L. subsp. *officinalis*; T scap; Paleotemp.; (Z.a)
Papaver rhoeas L. subsp. *rhoeas*; T scap; Paleotemp.; (C.)
Papaver setigerum DC.; T scap; Med.; (C.)

Familia PHYTOLACCACEAE

Phytolacca americana L.; G rhiz; Nat., N America; (n)

Familia PLANTAGINACEAE

Antirrhinum siculum Miller; Ch frut; End. It.-sic.; (C., Z.a)
Callitriche truncata Guss. subsp. *truncata*; I rad; Med.-Atl.; VU; (Z.a)
Kickxia commutata (Bernh.) Fritsch subsp. *commutata*; H rept; Med.; (C.)
Kickxia elatine (L.) Dumort. subsp. *elatine*; T scap; Euro-Med. (n)
Linaria reflexa (L.) Desf.; T rept; C Med.; (C., Z.a)
Plantago afra L. subsp. *afra*; T scap; Med.; (C., Z.a)
Plantago lagopus L.; T scap; Med.; (C., Z.a)
Veronica arvensis L.; T scap; Paleotemp.; (C., Z.a)
Veronica cymbalaria Bodard; T scap; Med.; (C., Z.a)
Veronica hederifolia L.; T scap; Paleotemp.; (Z.a)
Veronica polita Fries; T scap; Circumbor.; (Z.a)

Familia PLUMBAGINACEAE

Plumbago europaea L.; Ch frut; Med. (n)

Familia POLYGONACEAE

Polygonum aviculare L.; T rept; Boreo-Trop.; (n)

Rumex bucephalophorus L. subsp. *bucephalophorus*; T scap; Med.; (Z.a)
Rumex patientia L.; H scap; Nat., E Europe; (Z.a)
Rumex pulcher L. subsp. *pulcher*; H scap; Med.-Atl.; (C.)

Familia PORTULACACEAE

Portulaca oleracea L. subsp. *oleracea*; T scap; Boreo-Trop.; (C.)

Familia PRIMULACEAE

Anagallis arvensis L.; T rept; Boreo-Trop.; (C.)
Anagallis foemina Miller; T rept; Boreo-Trop.; (Z.a)
Samolus valerandi L.; H caesp; Boreo-Trop.; (C., Z.a)

Familia RANUNCULACEAE

Anemone coronaria L.; G bulb; Med.; (n)
Clematis vitalba L.; P lian; Euro-Med.; (Z.b)
Nigella damascena L.; T scap; Med.; (n)
Ranuncuus bullatus L.; H ros; N Med.; (n)
Ranunculus muricatus L.; T scap; Med.; n

Familia RESEDACEAE

Reseda alba L.; T scap; Med.; (C., Z.a)

Familia RHAMNACEAE

Rhamnus alaternus L.; P caesp; Med.; (C., Z.a)

Familia ROSACEAE

Pyrus spinosa Forssk.; P caesp; Med.; (Z.b)
Rubus ulmifolius Schott; NP; Euro-Med.; (C., Z.a)
Sarcopoterium spinosum (L.) Spach; NP; E Med.; LR; (n)

Familia RUBIACEAE

Asperula aristata L. fil. subsp. *scabra* (Presl) Nym.; H scap; Euro-Med.; (n)
Crucianella angustifolia L.; T scap; Med.; (Z.a)
Galium murale (L.) All.; T scap; Med.; (Z.a)
Galium aparine L.; T scap; Paleotemp.; (C.)
Galium verrucosum Huds. subsp. *verrucosum*; T scap; Euro-Med.
Rubia peregrina L.; P lian; Med. (n)
Sherardia arvensis L.; T scap; Euro-Med.; (Z.a)
Valantia muralis L.; T scap; Med.; (C., Z.a)

Familia RUTACEAE

Ruta chalepensis L.; Ch suffr; Med.; (Z.a)

Familia SCROPHULARIACEAE

Scrophularia peregrina L.; T scap; Med.; (C.)
Verbascum sinuatum L.; H bien; Med.; (C.)

Familia SIMAROUBACEAE

Ailanthus altissima (Miller) Swingle; P scap; Nat., China; (n)

Familia SOLANACEAE

Hyoscyamus albus L.; T scap; Med.; (C.)
Mandragora autumnalis Bertol.; H ros; Med.; (C.)
Solanum nigrum L. subsp. *nigrum*; T scap; Boreo-Trop.; (C.)

Familia ULMACEAE

Celtis australis L.; P scap; Med.; (Z.a)

Familia URTICACEAE

Parietaria judaica L.; H scap; Euro-Med.-Iran.-Tur; (C., Z.a)
Parietaria lusitanica L. subsp. *lusitanica*; T rept; Med.; (C.)
Urtica membranacea Poiret; T scap; Med.; (C.)

Familia VERBENACEAE

Lantana camara L.; P caesp; Nat., Trop. America; (C.)
Verbena officinalis L.; H scap; Boreo-Trop.; (C.)

Familia ZYGOPHYLLACEAE

Tribulus terrestris L.; T rept; Cosmop.; (C.)

ANGIOSPERMAE (Monocotyledones)
Familia ARACEAE

Arisarum vulgare Targ.-Tozz.; G rhiz; Med.; (C., Z.a)
Arum italicum Miller; G rhiz; Med.-Atl.; (Z.a)

Familia CYPERACEAE

Carex cuprina (Sandor ex Heuffel) Nendtwich ex A. Kern.; H caesp ; Euro-Med.-Iran.-Tur.; (n)
Carex divisa Hudson; G rhiz; Med.-Atl.; (Z.b)
Cyperus aureus Ten.G rhiz; Med.-Trop.; (C.)
Cyperus longus L. subsp. *badius* (Desf.) Asch. et Gr.; G rhiz; Med.; (n)
Cyperus rotundus L.; G rhiz; Med.-Trop.; (C.)

Familia IRIDACEAE

Gladiolus italicus Mill.; G bulb; Med.-Iran.-Tur.; (n)
Gynandriris sisyrinchium (L.) Parl.; G bulb; Med.; (Z.a)
Gynandriris todaroana Cif. et Giac.; G rhiz; End. sic.-sard.-cors.; (Z.a); not found now
Hermodactylus tuberosus (L.) Salisb.; G rhiz; N Med.; (n)
Iris florentina L.; G rhiz; Nat., unknown origin ; (Z.b)
Iris planifolia (Miller) Dur. et Sch.; G bulb; W Med.; (Z.a)
Romulea bulbocodium (L.) Sebast. et Mauri; G bulb; Med.; (n)

Familia JUNCACEAE

Juncus ambiguus Guss.; T caesp; Cosmop.; (Z.a) not found now
Juncus bufonius L.; T caesp; Boreo-Trop.; (n)
Juncus foliosus Desf.; T scap; SO-Med.; (n)
Juncus hybridus Brot.; T caesp; Euro-Med.; (n)

Familia ALLIACEAE

Allium neapolitanum Cyr.; G bulb; Med.; (Z.b)
Allium roseum L.; G bulb; Med.; (C.)
Allium obtusiflorum DC.; G bulb; End. Sicily (collected by Brullo in 1980, [Brullo et al. 1994] not found now)
Nothoscordum gracile (Aiton) Stearn; G bulb.; Nat., America; (n)

Familia AMARYLLIDACEAE

Narcissus serotinus L.; G bulb; Med.; (n)

Familia ASPARAGACEAE

Asparagus acutifolius L.; NP; Med.; (C.)
Asparagus albus L.; NP; W Med.; (n)

Familia ASPHODELACEAE

Asphodelus fistulosus L.; H bien; Med.; (C., Z.a)
Asphodelus ramosus L.; G rhiz; Med.; (C.)

Familia HYACINTHACEAE

Bellevalia romana (L.) Sweet; G bulb; Med.; (Z.a)
Charybdis pancration (Steinh.) Speta; G bulb; Med.; (C.)
Melomphis arabica (L.) Raf.; G bulb; Med.; (n)
Muscari parviflorum Desf.; G bulb; Med.; LR; (C.)
Ornithogalum gussonei Ten.; G bulb; E Med.; (Z.a)
Prospero autumnale (L.) Speta; G bulb; Med.; (n)

Familia RUSCACEAE

Ruscus hypophyllum L.; Ch frut; SW Med.; (Z.a)

Familia LEMNACEAE

Lemna minor L.; I nat; Boreo-Trop.; (n)

Familia ORCHIDACEAE

Ophrys sicula Tineo; G bulb; Med.; (n)
Orchis papilionacea L. var. *grandiflora* Boiss.; G bulb; W Med.; (C.)
Serapias lingua L.; G bulb; Med.-Atl. (n)

Familia ARECACEAE

Chamaerops humilis L.; P scap; W Med.; (C.)
Washingtonia robusta H.Wendl.; P scap; Nat.; Messico (n)

Familia POACEAE

Andropogon distachyos L.; H caesp; Med.; (C., Z.a)
Anisantha diandra (Roth) Tzvelev; T scap; Euro-Med.; (C.)
Anisantha fasciculata (C. Presl) Nevski; T scap; Med.; (C.)

Anisantha madritensis (L.) Nevski; T scap; Med.-Atl. (C., Z.a)
Anisantha rigida (Roth) Hyl.; T scap; Med.; (Z.a)
Anisantha rubens (L.) Nevski; T scap; Med.-Iran.-Tur.; (C.)
Anisantha sterilis (L.) Nevski; T scap; Paleotemp.; (C.)
Anthoxanthum gracile Biv.; T scap; S Med.; (Z.b)
Avena barbata Potter; T scap; Cosmop.; (C., Z.a)
Avena sterilis L.; T scap; Med.; (C.)
Bromus alopecuros Poir.; T scap; Med; (C.)
Catapodium rigidum (L.) Hubbard subsp. *rigidum*; T scap; Euro-Med.-Iran.-Tur.; (C.)
Cynodon dactylon (L.) Pers.; G rhiz; Boreo-Trop.; (C., Z.a)
Cynosurus echinatus L.; T scap; Med.; (Z.a)
Dactylis hispanica Roth; H caesp; Med.; (Z.a)
Dactyloctaenium aegyptium (L.) Richter; T rept; Nat., subtrop.; (n)
Dasypirum villosum (L.) Borbás; T scap; Med.-Iran.-Tur.; (Z.a)
Digitaria sanguinalis (L.) Scop. subsp. *sanguinalis*; T scap; Boreo-Trop.; (C., Z.a)
Echinochloa colonum (L.) Link; T scap; Boreo-Trop.; (Z.a)
Echinochloa crus-galli (L.) Beauv.; T scap; Boreo-Trop.; (C., Z.a)
Eragrostis minor Host; T scap; Circumbor.; (C.)
Eragrostis pilosa (L.) P. Beauv.; Cosmop.; (n - new record for Hyblaean district)
Hordeum leporinum Link; T scap; Med.; (C., Z.a)
Hyparrhenia hirta (L.) Stapf; H caesp; Med.-Trop.; (C., Z.a)
Hyparrhenia sinaica (Delile) Llauradò; H caesp; Med.-Trop.; (Z.a)
Lagurus ovatus L. subsp. *ovatus*; T scap; Med.; (Z.a)
Lamarckia aurea (L.) Moench; T scap; Med.-Iran.-Tur., (C., Z.a)
Lolium perenne L.; H caesp; Circumbor.; (Z.a)
Panicum repens L.; G rhiz; Med.-Trop.; (C., Z.a)
Phalaris minor Retz.; T scap; Med.-Iran.-Tur.; (C.)
Piptatherum miliaceum (L.) Coss.. subsp. *miliacea*; H caesp; Med.-Atl.; (C., Z.a)
Poa annua L.; T caesp; Cosmop.; (C.)
Poa infirma H.B.K.; T caesp; Med.; (n)
Poa bulbosa L.; H caesp.; Paleotemp.; (n)
Polypogon monspeliensis (L.) Desf.; T scap; Med.-Trop.; (n)
Polypogon maritimus Willd.; T scap; Med.-Iran.-Tur.; (n)
Polypogon viridis (Gouan) Breistr.; H caesp; Med.; (C., Z.a)
Setaria verticillata (L.) Beauv.; T scap; Boreo-Trop.; (C.)
Sorghum halepense (L.) Pers.; G rhiz; Med.-Trop.; (C.)
Stipa capensis Thumb.; T scap; Med.; (C., Z.a)
Trachynia distachya (L.) Link; T scap; Med.-Iran.-Tur.; (C.)
Trisetaria aurea (Ten.) Pign.; T scap; C Med.; (Z.a)
Vulpia myuros (L.) Gmelin; T caesp; Boreo-Trop.; (C.)

Familia TYPHACEAE

Typha angustifolia L.; G rhiz; Cosmop.; (C.)

HABITATS OF COMMUNITY INTEREST AND PROPOSAL FOR S.C.I. INSTITUTION

Despite the vegetation features occurring in the archaeological site are not examined in this paper, since already treated by Corbetta et al. (2012) and Minissale & Sciandrello (2016), here it would point out that in the entire archaeological area of Neapolis, including the non-fenced area placed west of the Greek Theater, which extends to the cemetery in Syracuse, occupying the non urbanized part of “Colle Temenite”, there are habitats of Community interest deserving of protection which could be safeguarded, not only in an indirect way by the archaeological restrictions, but also by the establishment of a Site of Community Importance (S.C.I.). In this way good management practices could be introduced and it might be also a legal bulwark against new property speculation that, after the great urban expansions of the 60s and 70s of the last century, do not cease to surround and threaten these sites.

In the area the habitats of Annex I of the European Directive 93/42 EEC, which justify the institution of a Site of Community importance (S.C.I.), are the following:

3170*: Mediterranean temporary ponds, corresponding to temporary pondsa characterized by amphibious community of the *Isoeto-Nanojuncetea* class with *Elatine gussonei* and *Tillaea vaillantii*;

5420: *Sarcopoterium spinosum* phryganas: in this habitat can be included scrubland with *Origanum onites* which is associated with *Corido-*

thymus capitatus and sometimes *Sarcopoterium spinosum*;

6220*: Mediterranean xeric grasslands (*Thero-Brachypodietea*): here including the grasslands dominated by *Hyparrhenia hirta*, but also arid ephemeral grasslands, such as those dominated by *Sedum coeruleum* that colonizes the rock with reduced soil and the grasslands dominated by *Stipa capensis* which prefers a more thick soil.

The rocky habitats, being of artificial origin, although older than 2000 years, still do not host the typical rocky flora, except *Antirrhinum siculum*, and therefore they can not be ascribed to the category as specified in Annex I.

The presence in the study area of the endemic *Elatine gussonei* is of great importance since it is among the few Italian plant species of Community interest included in Annex II of the Habitats Directive, whose conservation requires the designation of special areas of conservation. This is particularly true for the habitat of temporary pools with endemic species not always well protected by the Natura 2000 network as recently highlighted by Bagella et al. (2013).

CONCLUSIONS

The plant cover, both natural and cultivated, of the archaeological park contributes to characterize the site and, as we have seen, it can provide points of interest for visitors, which go far beyond just ornamental value, landscaping or the possibility of having shade and cool in summer; but as evidenced by Minissale et al. (2016), it requires precise and regular management interventions. In particular the “positive” botanical emergencies found in the archaeological site and surrounding areas must be protected with great care; they represent an important natural heritage that enriches the value of the archaeological site and in some cases they are the expression of human actions that occurred in antiquity; including quarry activities of stone blocks that have increased the presence of micro-sites with temporary pools suitable for the flora. On the other hand the problem of invasive alien species should not be underestimated; although very recently, it is likely to become a serious threat to the archaeological site as a whole; therefore, the control of invasive species must be continuous and prolonged in time.

Good management of the “green” will facilitate access to areas, as most of the quarries, that before the works of 2013 were almost inaccessible. For these areas we highlight the opportunity to schedule some intervention to improve the ornamental green cover in order to differentiate it with a more Mediterranean footprint. In this regard, many species of the Mediterranean maquis and garrigue could be used, for the delimitation of the hedges currently made with *Pittosporum tobira* (Thunb.) W.T.Aiton, species of East Asia imported in Europe in XIX century. In this case the use of myrtle (*Myrtus communis* L.), a Mediterranean species, present in Hyblean area, would be especially suitable for the aroma emanating from the foliage and the beautiful summer bloom.

Besides, the creation of thematic paths within the Neapolis will be a valuable support to the use of the site including the purpose of inducing (at least some of the 500,000 visitors per year who access it) to learn more about this exceptional cultural and naturalistic heritage. In any case a rigorous protocol of sustainable use will have to be developed in order to avoid to damage or compromise the existence of the reported floristic peculiarities.

Finally, it is hoped that the scientific results briefly summarized in this article and in Minissale & Sciandrello (2016) can be interfaced with other skills to make them the subject of further scientific publications and dissemination editorial products useful to raise awareness to plant heritage respect, but also in order to plan a proper management of the archaeological site and the surrounding territory.

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MONOGRAPH

Preliminary data on the occurrence of alien macroalgae in the vermetid reef along the coasts of Favignana Island (Southern Tyrrhenian Sea)

Paolo Balistreri* & Anna Maria Mannino

Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche, Sezione di Botanica ed Ecologia vegetale, Università di Palermo, Via Archirafi 38, 90123 Palermo, Italy; e-mail: requin.blanc@hotmail.it; annamaria.mannino@unipa.it
*Corresponding author

ABSTRACT

Intertidal vermetid reefs are highly diverse systems that provide numerous habitats for animal and vegetal species, leading to an increase of intertidal biodiversity. These habitats, particularly vulnerable to environmental changes and human activities, are now experiencing high mortality in several areas of the Mediterranean Sea. Since alien macroalgae are nowadays considered one of the most serious threats to biodiversity and natural ecosystem functioning, we provide a first baseline assessment of the occurrence of alien species in the vermetid reef along the coasts of the Island of Favignana (Egadi Islands Marine Protected Area). Surveyes carried out in 2015 revealed the only presence of *Caulerpa cylindracea* Sonder (Bryopsidales Caulerpaceae). The alga, exclusively recorded within the cuvettes, showed low values of abundance (class 1: cover <10%) except for San Giuseppe and Punta Longa localities where the values of abundance fell within the class 3 (cover <40% and >20%). No significant correlations were highlighted between the abundance values of *C. cylindracea* and those of the dominant macroalgae inhabiting the cuvettes.

KEY WORDS Alien macroalgae; Favignana Island; southern Tyrrhenian Sea; vermetid reef.

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INTRODUCTION

The Mediterranean Sea is one of the most severely affected areas by biological invasions, a “sea under siege” (Galil, 2000; Boudouresque et al., 2005; Rilov & Galil, 2009). The number of alien marine species reported so far ranges from more than 600 to nearly 1.000 (Zenetos et al., 2012; Galil & Goren, 2014). As far as marine macrophytes are concerned, a total of one hundred and thirty three species have been listed as possible aliens; of these, 23 belong to the Chlorophyta, 79 to the Rhodophyta, 30 to the Ochrophyta, and one is a seagrass species (Tracheophyta) (Verlaque et al., 2015). At present, 52 non-indigenous macroalgae are reported from the Italian coasts, 6 Chlorophyta, 9 Ochrophyta, 36 Rhodophyta and 1 aquatic angiosperm (Sfriso & Marchini, 2014). Among them the invasive taxa belonging to the genus *Caulerpa* (Bryopsidales Caulerpaceae), *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman et Boudouresque, thereafter reinstated to its species rank as *C. cylindracea* Sonder (Belton et al., 2014), *C. taxifolia* (Vahl) C. Agardh and *C. taxifolia* (Vahl) C.

Agardh var. *distichophylla* (Sonder) Verlaque, Huisman et Procaccini, recently recorded in Sicily (in 2007 as *C. distichophylla* in Meisnez et al., 2010; Jongma et al., 2013; Musco et al., 2014), have raised serious ecological and economic concern.

Sicily and smaller surrounding Islands, located at the crossroads between the eastern and western sectors of the Mediterranean Sea and characterized by intense maritime traffic (Occhipinti-Ambrogi et al., 2011; Coll et al., 2012; Katsanevakis et al., 2014), are particularly vulnerable and suitable to biological marine invasions (Bianchi, 2007; Occhipinti-Ambrogi et al., 2011; Katsanevakis et al., 2012; Papini et al., 2013; see also Figs. 2-5 in Katsanevakis et al., 2014) and then can be considered as important sources for secondary dispersal. Vermetid reefs are bioconstructions built up by the gastropod mollusc *Dendropoma cristatum* (Biondi, 1859) (Vermetidae) in association with some coralline algae such as *Neogoniolithon brassica-florida* (Harvey) Setchell et Mason. These bioconstructions play a fundamental structural role, as they protect coasts from erosion, regulate sediment transport and accumulation, serve as carbon sinks, make the habitat more complex and heterogeneous and provide numerous habitats for animal and vegetal species thus increasing intertidal biodiversity (Pandolfo et al., 1992, 1996; Badalamenti et al., 1998).

These biogenic constructions, enclosed in the SPA/BIO Protocol (Barcelona Convention) are now threatened by environmental changes and human activities (e.g. pollution, climate change, ocean acidification) thus experiencing high mortality in several areas of the Mediterranean Sea (Di Franco et al., 2011; Galil, 2013; Milazzo et al., 2014). Marine Protected Areas (MPAs), even though have a strong potential for habitat and biodiversity conservation, seem to be not effective in protecting from the different threats and then from biological invasions, sometimes enhancing them (e.g. Byers, 2005; Klinger et al., 2006; Burfeind et al., 2013). Since the increase of knowledge is essential for the conservation and protection of this highly valuable and vulnerable habitat, with this study we provide a first baseline assessment of the distribution and abundance of alien macroalgae in the vermetid reefs present along the coasts of Favignana Island (Egadi Islands MPA).

MATERIAL AND METHODS

Study area

The study was carried out at Favignana Island (Egadi Islands MPA), located approximately five kilometers from the western coast of Sicily. The Island, part of the Aegadian Archipelago, represents an example of a lower Pleistocene bioclastic calcarenite, characterized by a typic association known as foramol (Kil, 2010). More or less continuous vermetid reefs are present along the coasts of Favignana, consistent with the true reefs described along the north-western Sicilian coasts (Antonioli et al., 1999; Chemello, 2009). Their distribution confirms the need of carbonatic substrates and of an abrasion platform for the formation of true reefs (Dieli et al., 2001). Recently, a preliminary description of the reefs present along the coasts of Favignana Island was provided (Balistreri et al., 2015; Table 1).

Sampling and Data analysis

Surveys were carried out in summer 2015 in ten areas, characterized by the presence of a vermetid reef (Fig. 1). Five areas were selected along the northern side: Faraglione, Pozzo, Arre Turinu, San Giuseppe, San Nicola, and five along the southern side:

Pattern 1	**Outer Margin**: wide, flattened and irregular. In the inner side, crevices were also present. **Inner Margin**: *Dendropoma cristatum* is absent. **Cuvettes**: not many, not deep and with a variable width.
Pattern 2	**Outer Margin**: thin and not continuously arranged. **Inner Margin**: *Dendropoma cristatum* is absent. **Cuvettes**: not many and not deep.
Pattern 3	**Outer Margin**: it has a variable height and sometimes it is absent. Some crevices can also be present together with regrowth areas. **Inner Margin**: *Dendropoma cristatum* is absent. **Cuvettes**: many and sometimes very deep.

Table 1. Local patterns of vermetid reef observed at Favignana Island (Balistreri et al., 2015).

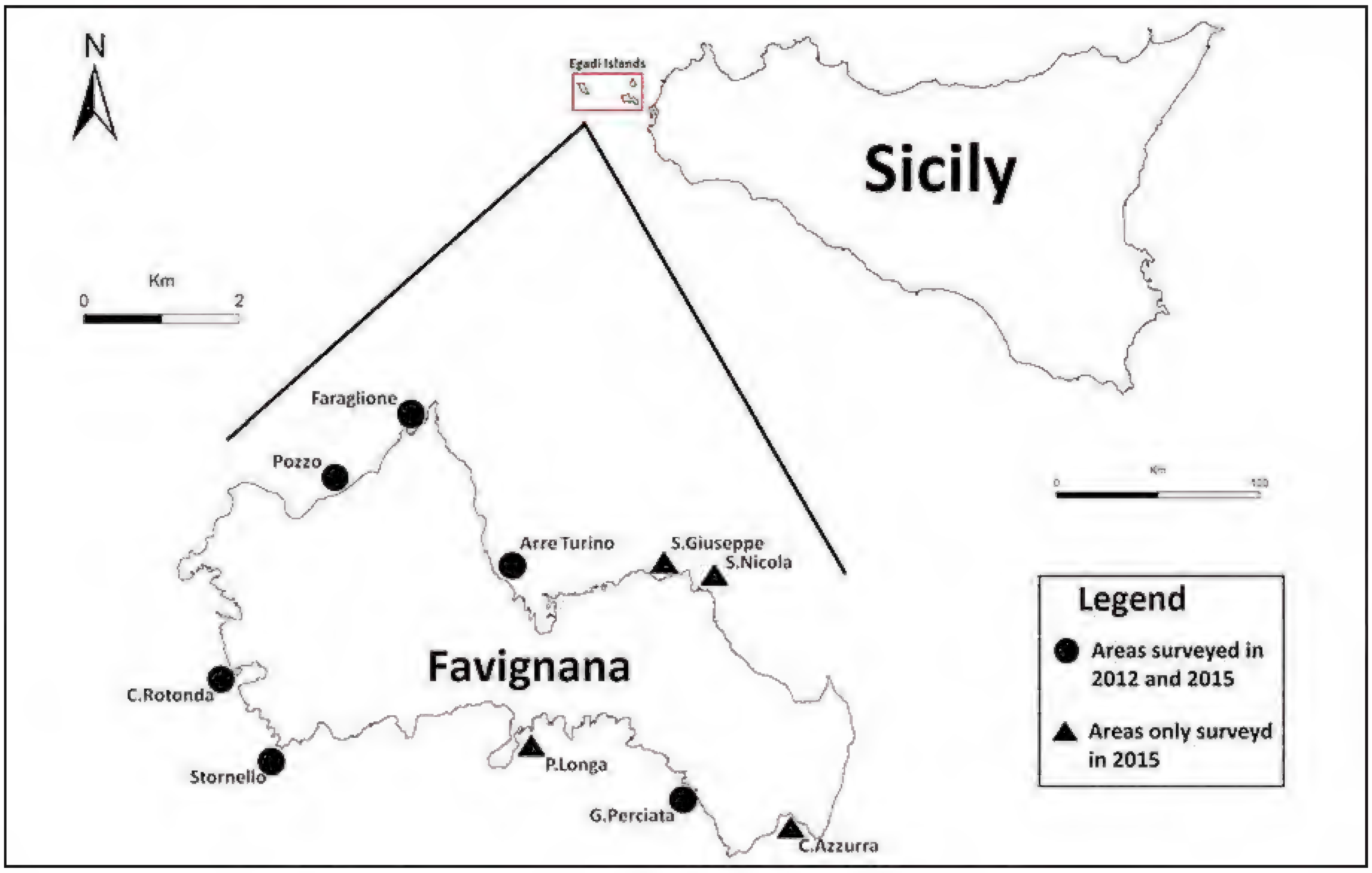
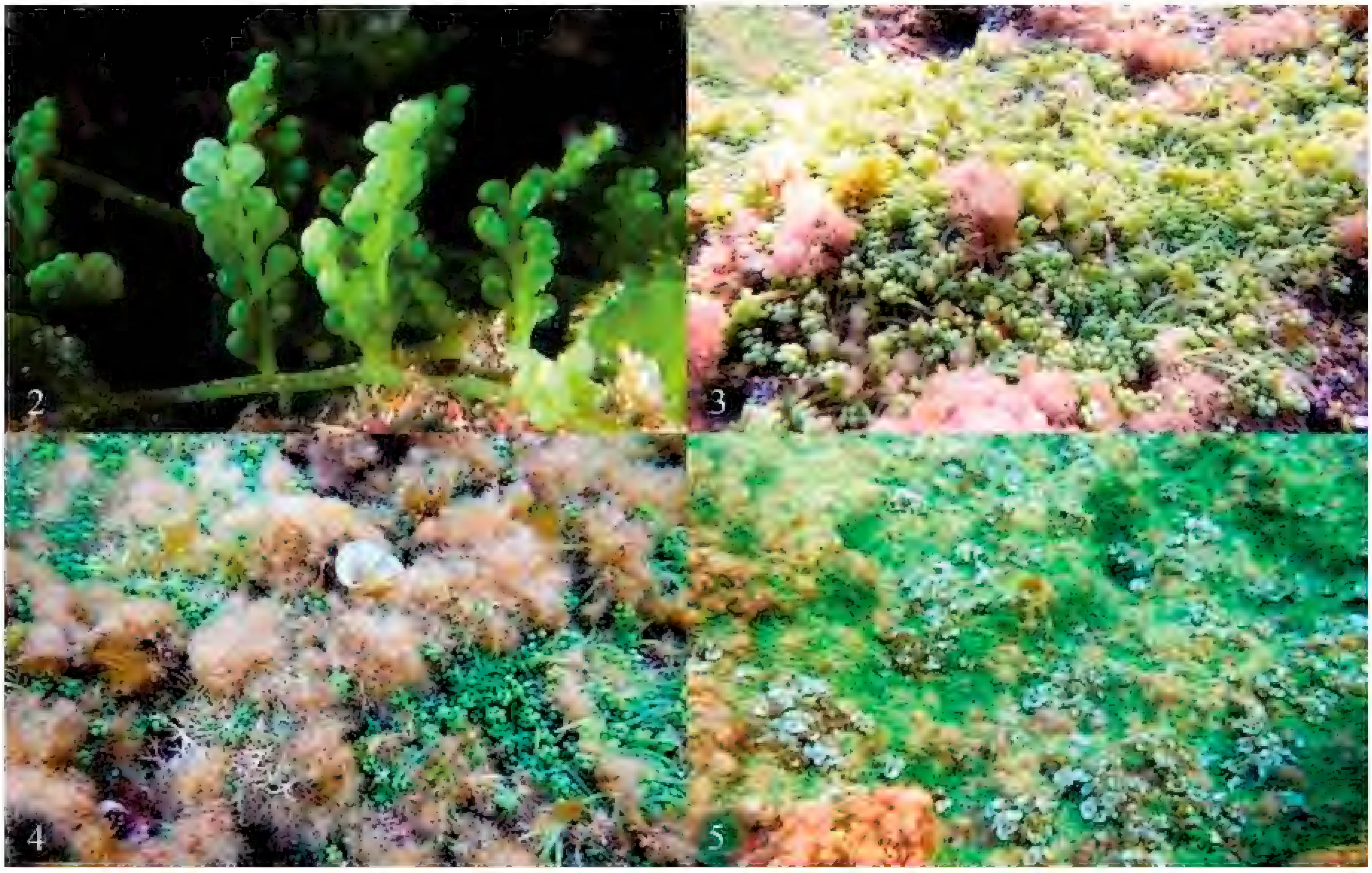

N
Km
0
2
Egadi Islands
Sicily
Faraglione
Pozzo
Arre Turino
S.Giuseppe
S.Nicola
Favignana
C.Rotonda
Stornello
P.Longa
G.Perciata
C.Azzurra
Km
0
100
Legend
● Areas surveyed in 2012 and 2015
▲ Areas only surveyd in 2015

Figure 1. Location of the study areas at Favignana Island.



Figures 2–5. *Caulerpa cylindracea*. Fig. 2: Habit (photo by Fabio Russo). Figs. 3, 4: Patches within cuvettes, the stolons of *Caulerpa cylindracea* are strictly intermingled with the thalli of other macroalgae (San Giuseppe). Fig. 5: A patch beneath the reef (San Giuseppe).

Grotta Perciata, Cala Rotonda, Stornello, Punta Longa, Cala Azzurra. These areas were surveyed in order to check the presence of alien macroalgae. Six of the studied areas (Faraglione, Pozzo, Arre Turinu, Grotta Perciata, Cala Rotonda, Stornello) were already checked for the presence of alien species in summer 2012 (Balistreri, 2011/2012). The macroalgal community inhabiting the reef was also analysed in terms of abundance values of the dominant taxa. Abundance values of the alien taxa together with those of the dominant macroalgae were estimated, as substratum cover (%), by placing six replicated 400 cm^2 quadrats within the colonized surface, and five classes were considered: 1 (cover <10%), 2 (cover <20% and >10%), 3 (cover <40% and >20%), 4 (cover <60% and >40%) and 5 (cover >60%).

RESULTS

The surveys showed the only presence of *C. cylindracea* (Fig. 2), generally forming isolated patches within the cuvettes of the vermetid reef (Figs. 3, 4). Moreover, it has been observed that the stolons of *C. cylindracea* frequently grew strictly intermingled with the thalli of other macroalgae, leading to a complex web (Figs. 3, 4).

The alga was totally absent at Faraglione, Grotta Perciata, Pozzo and Stornello (Table 2). The abundance values of *C. cylindracea* were low and fell within the class 1 (cover <10%), with the exception of Punta Longa and San Giuseppe, where the abundances fell within the class 3 (cover <40% and >20%) (Table 2). At San Giuseppe, patches of *C. cylindracea* were more or less continuously present up to 1 m depth (Fig. 5) whereas at Cala Azzurra only isolated thalli were present beneath the reef. The macroalgal community inhabiting the cuvettes was dominated by the following five taxa: *Cystoseira amentacea* (C. Agardh) Bory, *Halopteris scoparia* (Linnaeus) Sauvageau, *Jania rubens* (Linnaeus) J.V. Lamouroux, *Laurencia obtusa* (Hudson) J.V. Lamouroux and *Padina pavonica* (Linnaeus) Thivy. No significant correlations were highlighted between the abundance values of *C. cylindracea* and those of the dominant macroalgae (Table 3).

Study area	*Reef pattern*	*2012*	*2015*
Faraglione	1	1	-
Pozzo	1	1	-
Arre Turino	3	-	1
Grotta Perciata	2	1	-
Stornello	2	1	-
Cala Rotonda	3	-	1
San Giuseppe	2	ms	3
San Nicola	1	ms	1
Cala Azzurra	2	ms	1
Punta Longa	2	ms	3

Table 2. Classes of abundance of *Caulerpa cylindracea* in 2012 and 2015 (ms = missing data, - = absent).

DISCUSSION AND CONCLUSIONS

Caulerpa cylindracea, the only alien species we recorded, was exclusively present within the cuvettes and generally showed a patchy distribution. Low abundance values were registered, with the exception of Punta Longa and San Giuseppe.

Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, observed in summer 2008 only at San Giuseppe within the cuvettes near the outer margin of the reef (Balistreri, 2009/2010; Fig. 6), was totally absent both in 2012 and 2015.

The comparison with data obtained from surveys carried out in 2012 highlighted some differences in the distribution of *C. cylindracea*. In particular, at Faraglione, Grotta Perciata, Pozzo and Stornello the alga, recorded in 2012, was totally absent in 2015 whereas at Arre Turino and Cala Rotonda it was absent in 2012 but was present in 2015 (Table 2). In both years low abundance values were registered.

At the moment the presence of *C. cylindracea* doesn't raise serious concern in the studied areas. However, as it is a highly successful species (Carruthers et al., 1993; Ceccherelli et al., 2000; Ceccherelli & Piazzi, 2001; Raniello et al., 2007; Occhipinti-Ambrogi et al., 2011; Felline et al., 2012; Gorbi et al., 2014) and MPAs seem to be not effective in protecting from the different threats and then from biological invasions, its spread and distribution should be regularly monitored. Moreover, since this species takes advantage of ecosystem degradation (Occhipinti-Ambrogi & Savini, 2003), making fragmented or less structured habitats highly vulnerable to its invasion (Ruitton et al.,

Taxa		**Classes of abundance**									
		Faraglione	**Pozzo**	**Arre Turino**	**Grotta Perciata**	**Stornello**	**Cala Rotonda**	**San Giuseppe**	**San Nicola**	**Cala Azzurra**	**Punta Longa**
R	*Jania rubens*	1	0	1	2	0	1	4	2	2	0
R	*Laurencia obtusa*	1	1	1	1	1	0	0	2	1	0
O	*Cystoseira amentacea*	4	4	3	4	4	4	2	0	3	3
O	*Halopteris scoparia*	0	0	1	0	0	0	2	2	0	0
O	*Padina pavonica*	0	1	3	1	0	0	1	1	0	0
C	*Caulerpa cylindracea*	0	0	1	0	0	1	3	1	1	3

Table 3. Classes of abundance of *Caulerpa cylindracea* and the dominant macroalgae in 2015 (R = Rhodophyta, O = Ochrophyta, C = Chlorophyta).

2005; Bulleri et al., 2010, 2011; Katsanevakis et al., 2010), effective management and conservation strategies have to be planned within the MPA.

The vermetid reef is a highly vulnerable habitat, characterised by a delicate balance between two opposite processes, deposition and erosion, with the balance generally tilting toward deposition (Chemello & Silenzi, 2011), even though "*the structure can undergo a kind of 'suicide' leading to its destruction by catastrophic events*" (Antonioli et al., 1999; Chemello & Silenzi, 2011). Moreover, increases in sedimentation might enhance the invasiveness of alien species such as *C. cylindracea* (Airoldi & Cinelli, 1997; Piazzi et al., 2007). Indeed, this alga is able to tolerate high sedimentation rates and its spread and competitive ability may be enhanced by sediment deposition as consequence of its ability to trap sediments (Piazzi et al., 2005, 2007). As consequence of its active mechanism of stolonisation it forms compact multilayered mats together with macroalgae, that traps sediment creating a relevant decrease of redox potential underneath (Piazzi et al., 1997, 2005, 2007; Klein & Verlaque, 2008; Mannino & Di Giovanni, 2011; Matijević et al., 2013). This mat may negatively affect the benthic assemblages (in term of diversity and structure), alters sediment conditions, causes drastic reductions in diversity of the infaunal compartment

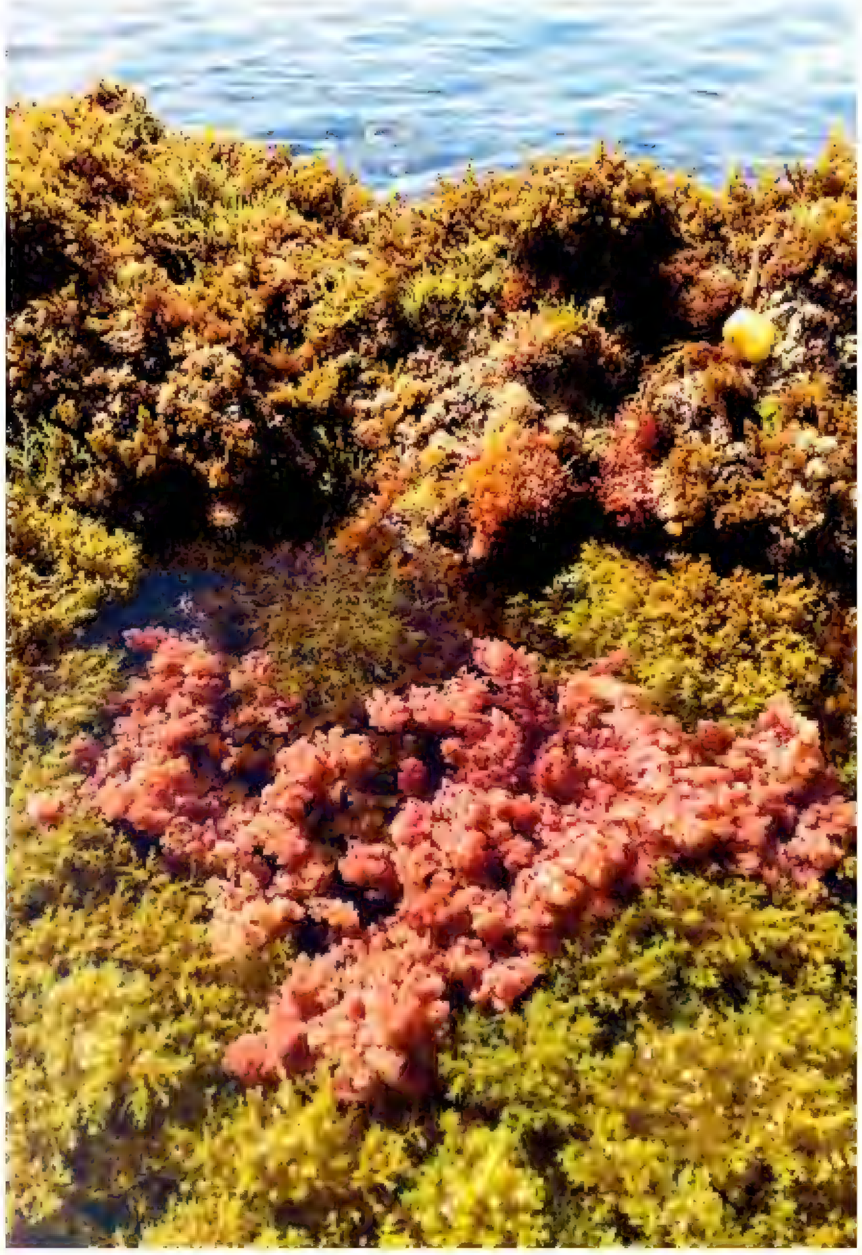


Figure 6. Thalli of *Asparagopsis taxiformis* (San Giuseppe).

(Antolić et al., 2008; Klein & Verlaque, 2008; Baldacconi & Corriero, 2009; Holmer et al., 2009; Žuljević et al., 2011) and directly affect reproduction of demersal species (Felline et al., 2012).

Since areas located at the crossroads between the eastern and western sectors of the Mediterranean, like Sicily and the circum-Sicilian Islands, are more vulnerable to biological marine invasions, regular monitoring programs, including public awareness campaigns (e.g. the project entitled "Progetto *Caulerpa cylindracea* - Egadi" sponsored by the Department of Biological Chemical and Pharmaceutical Sciences and Technologies, University of Palermo and the Egadi Islands MPA and available at http://www.ampisoleegadi.it/progetto_caulerpa_cylindracea_egadi.html), regular surveys and mapping by scientists, are strongly needed to assess the spread dynamics of invasive species not only within the protected areas (i.e. MPAs and Natural Reserves), but also in their surroundings in order to reduce continuous spillover effects (see also Otero et al., 2013). In the MPAs, high rates of visitation could promote the introduction of invasive species through increased disturbance and vectors (e.g., boat anchors, SCUBA equipment, bilge water, hull fouling) and subsequent dispersal of propagules (Minchinton & Bertness, 2003; West et al., 2007; Britton-Simmons & Abbott, 2008; Burfeind et al., 2013), therefore an Invasive Alien Species (IAS) strategy integrated into the management plan of the Egadi Islands MPA may be highly desirable.

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MONOGRAPH

Breeding of Black-necked Grebe *Podiceps nigricollis* C.L. Brehm, 1831 (Aves Podicipedidae) in the SCI and SPA ITA060002 “Lago di Pergusa” (Sicily, Italy)

Rosa Termine

“Kore” University of Enna, Laboratory of Sanitary Environmental Engineering - Section of Biology, Cittadella Universitaria - 94100 Enna, Italy; e-mail: rosa.termine@unikore.it

ABSTRACT On 2015 breeding season, we censused a high number of *Podiceps nigricollis* C.L. Brehm, 1831 (Aves Podicipedidae), breeding in the SCI and SPA ITA060002 “Lago di Pergusa”, including the Nature Reserve “Lago di Pergusa”. After 1950 the breeding records of the *P. nigricollis* in Italy were of approximately twenty and relative to a few pairs. Since 2010, in the Lake Pergusa, the *P. nigricollis* has changed its status from “migratory, overwintering and irregular breeder” to “regular breeder”. In 2010, and more regularly in 2012–2015, there are in fact documented breeding attempts with relative offspring. This Lake has so far counted the largest number of breeding pairs for Sicily and Italy. We point therefore to the importance of this protected natural area as a breeding site for the *P. nigricollis*.

KEY WORDS Black-necked Grebe; nesting; Pergusa Lake; *Podiceps nigricollis*; Sicily.

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INTRODUCTION

After 1950 the breeding records of the *Podiceps nigricollis* C.L. Brehm, 1831 (Aves Podicipedidae) in Italy were of approximately twenty and relative to a few pairs (Brichetti & Fracasso, 2013; Verducci & Sighele, 2013).

In Sicily (Fig. 1), this specie was considered resident and regularly breeding (Benoit, 1840; Doderlein, 1873). Later on, only two breeding attempts were recorded: in 1957 in the Lake Pergusa (20–25 pairs approximately) (Krampitz, 1958) and in 1966 in Palermo province, in the Scanzano dam (1 pair) (Iapichino & Massa, 1989). For over thirty years on the Island there have been anecdotal sightings and irregular summer occurrence (AA.VV., 2008).

From 2000 to 2011 there were a few cases of breeding attempts: in 2000 and 2005 in Caltanissetta province (Mascara, 2007); in 2004, in 2006 (Corso, 2005, 2007) and 2011 (Di Blasi, pers. comm. 2011) in Siracusa province.

Since 2010, in the Lake Pergusa, the *P. nigricollis* has changed its status from “migratory, overwintering and irregular breeder” to “regular breeder”.

There are in fact documented breeding attempts with relative offspring:

- in 2010, with maximum observation of 16 adults at most and 13 chicks and juveniles together (Ientile et al., 2010; Termine et al., 2011);
- in 2012, with maximum observation of 50 adults at most and 49 chicks and juveniles together (Termine & Massa, 2015);

- in 2013, with maximum observation of 128 adults and 112 chicks and juveniles together (Termine & Massa, 2015).

In 2011, between April and July, there are records of 8 individuals with nuptial plumage, however at the end of June their number was already reduced to 2 and, given the absence of observations of new born chicks, there are hypotheses that those were summer residents (Termine & Massa, 2015).

MATERIAL AND METHODS

Main object of this study, the monitoring of *P. nigricollis*, was conducted from October 2013 to August 2015 by observation sessions at least every 15 days with 10x42 binoculars and 25÷50x80 telescope. We walked the whole lake perimeter with an electric boat to access sites not seen from the coast.

In the warm season, observation sessions were conducted in early mornings and late afternoon, thus during activity peak for water birds. Observation data were then inputted in a complete database.

Study area

The SCI and SPA ITA060002 "Lago di Pergusa" (EN) include the Nature Reserve "Lago di Pergusa" (402.5 hectares) created after the Regional Law No. 71 of 1995 and managed by the former Regional Province of Enna, now "Libero Consorzio Comunale".

The Lake Pergusa is a closed basin, approximately 140 hectares large and characterized by marked water level fluctuations influenced by both precipitations and summer evaporation that make their waters as brackish ones.

For about twenty years the Lake water level decreased gradually down to its almost complete disappearance in the summer 2002 following long drought periods and several anthropic actions started in '30s with land reclamation works and continuing throughout '60s and '70s with ground water draw from private and public wells.

Since 2003 the Lake water level has been instead increasing, because both precipitation increase and well closing, so that in the last years the level is recorded beyond 4 metres versus 27 centimetres in 2002, when the water deficit and

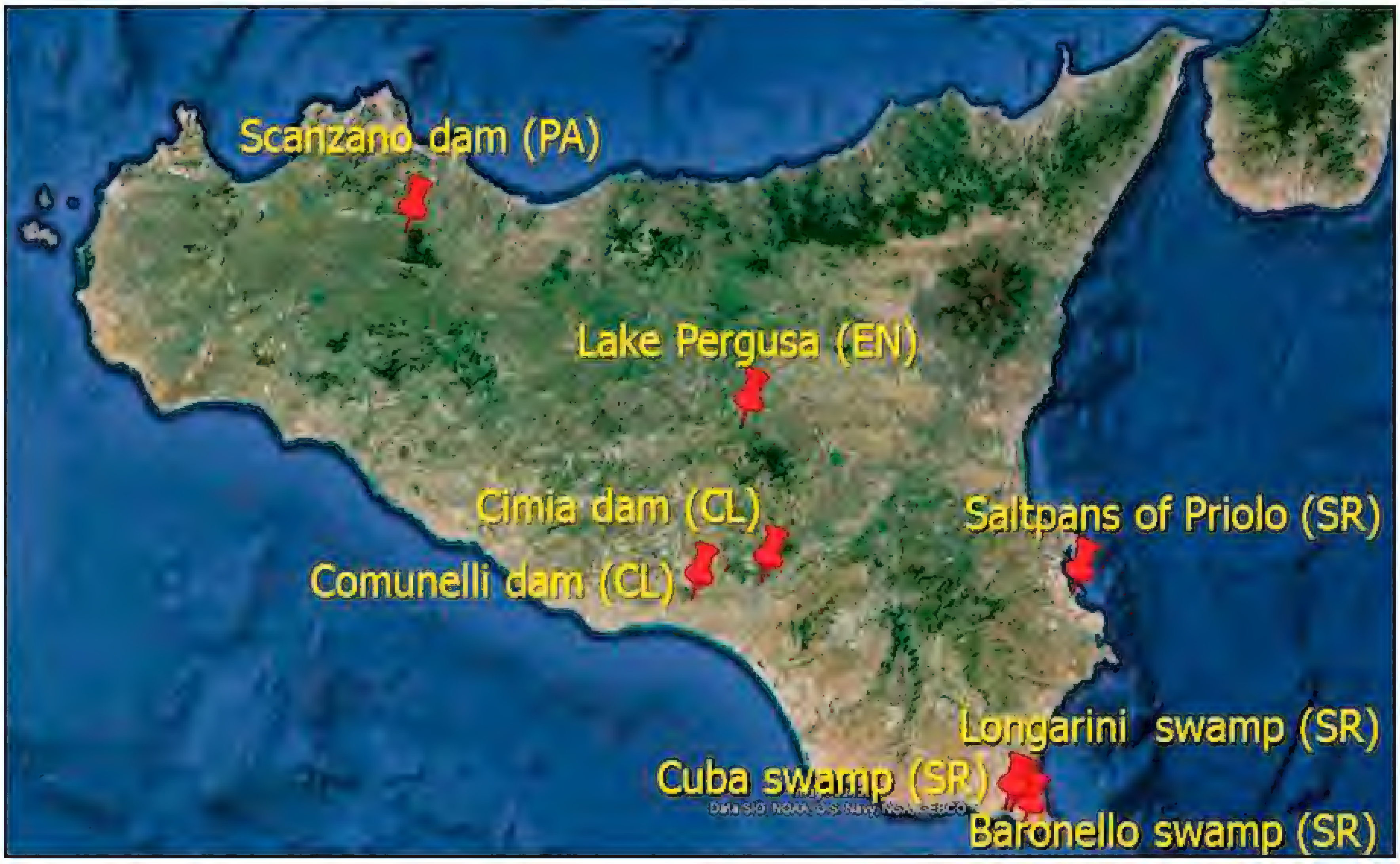
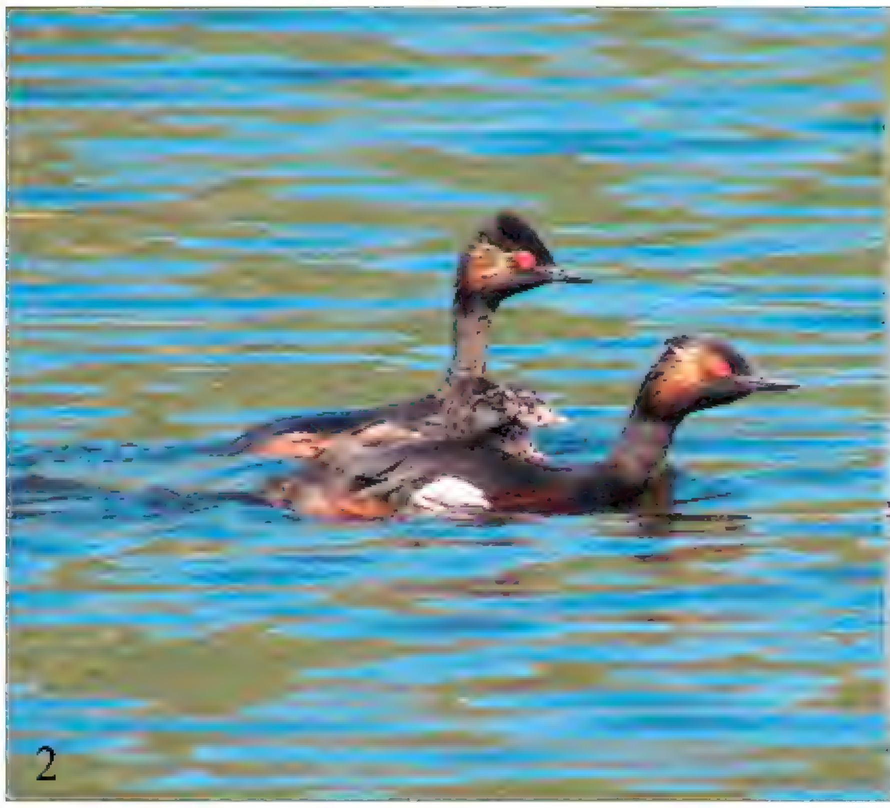


Figure 1. Breeding sites of *Podiceps nigricollis* in Sicily (1957–2015).



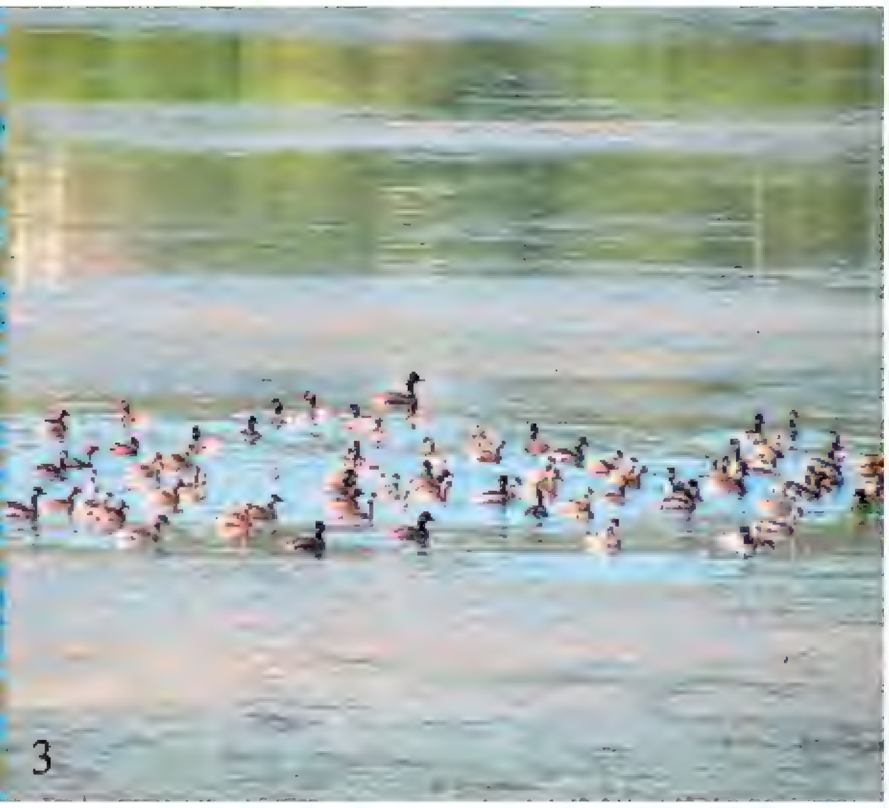


Figure 2. Swimming adult with three chicks on its back in the "Lago di Pergusa". Figure 3. Young grouped in large crèche.

the salty conditions were so marked that they resulted in an almost complete absence of its biotic component.

Controlled inflows of external water from the nearby Ancipa dam of Troina (Enna) have also contributed to the recovery of the Lake. Between 2002 and 2004, indeed, the managing body conducted a test for the environmental recovery of the Lake: 804,420 cubic metres of water were put in between December 11, 2002 and May 7, 2003, and 750,010 cubic metres of water were put in between March 29 and May 31, 2004. Each inflow represents 1/6 of the total lake volume, today estimated as approximately 4,500,000 cubic metres.

Despite its small size, the Lake hosts a rich avifauna; censuses recorded more than 170 species, including breeding, overwintering and migratory ones.

Some of them are with a specific conservation status; among the breeders, 18 species are included in the European lists SPEC, among these 5 species are included in the Annex I, Dir. 2009/147/CE: *Tyto alba* (Scopoli, 1769), *Calandrella brachydactyla* (Leisler 1814), *Aythya nyroca* (Güldenstädt, 1770), *Porphyrio porphyrio* (Linnaeus, 1758) and *Ixobrychus minutus* (Linnaeus, 1766). Moreover, 5 species are included in the Italian Red List: *Otus scops* (Linnaeus, 1758), *Tyto alba*, *Aythya nyroca*, *Porphyrio porphyrio* and *Ixobrychus minutus* (Termine et al., 2008).

RESULTS AND DISCUSSION

On the 18th February 2014, on 12 individuals, 6 were with nuptial plumage; 4 of them showed an intraspecific competition, whereas one individual with nuptial plumage and another with winter plumage appeared as a pair that was observed also on the following days; the breeding pairs were observed from May to October, with observation of maximum (Table 1, red font) 146 adults and 238 chicks and juveniles together.

On 17th February 2015, on 25 individuals, 13 were with a nuptial plumage; 6 of them showed an intraspecific competition; the breeding pairs were observed from May to August, with observation of maximum (Table 1, red font) 261 adults and 304 chicks and juveniles together.

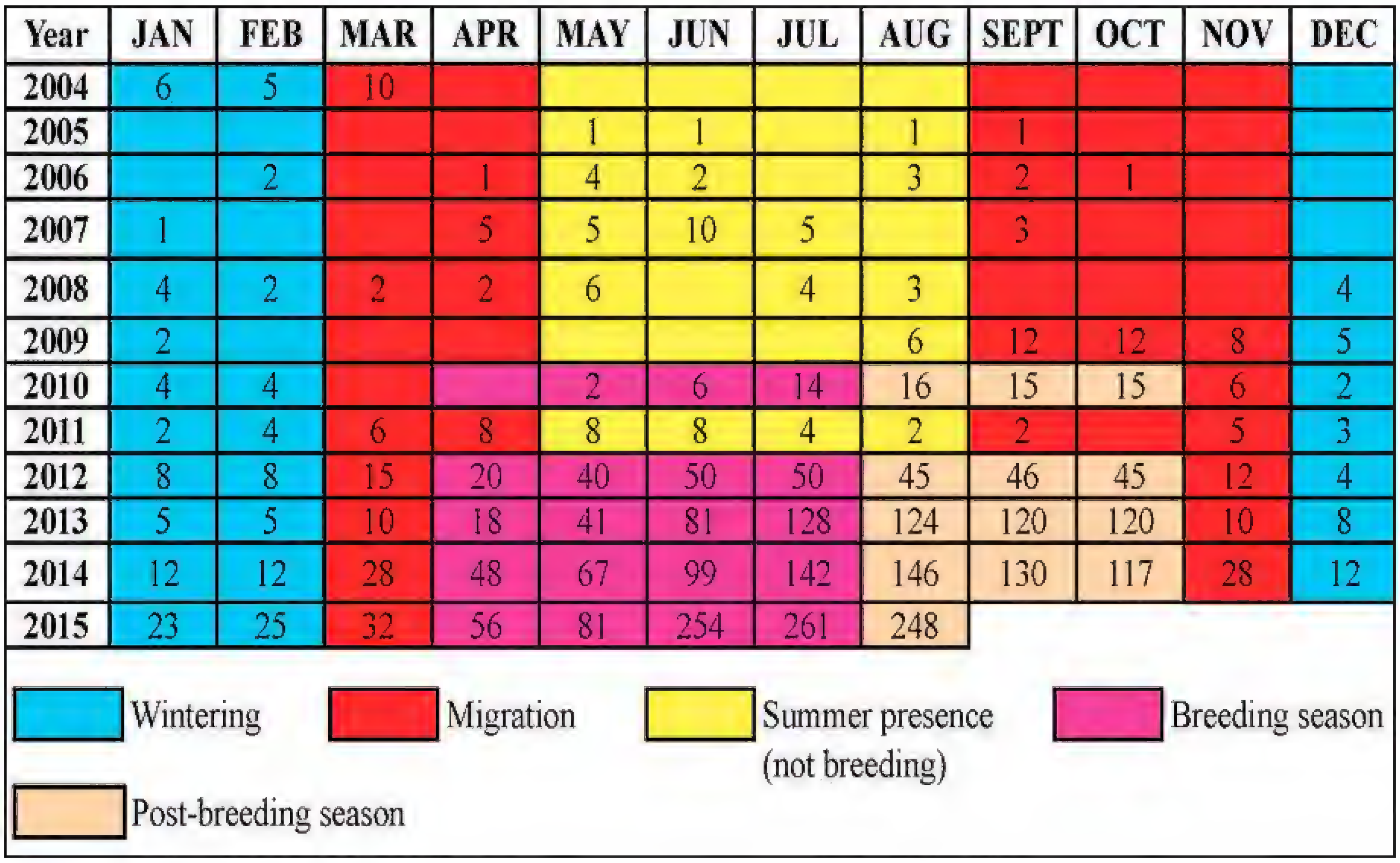
According to the observations conducted in Pergusa since 2010, the chicks are moved on the back, even two-three at once (Fig. 2) by both parents and they become independent at 2–3 week old although they keep staying with their parents; as the breeding season goes on, the pairs move close to each other, together with their offspring, until they form larger and larger groups.

Then starting in mid-August the young are grouped in large crèche (often only one), while some adults hang round the groups (Fig. 3) and other adults move to different directions getting sometimes far from the groups.

Starting in mid-October young and adults

Date	Singles	Pairs	Tot. Adults	Pulli	Juv.	Total Pulli +Juv.
17.V.2014	65	1	**67**	1		**1**
15.VI.2014	19	37	**93**	68		**68**
29.VI.2014	21	39	**99**	27	53	**80**
13.VII.2014	12	65	**142**	113	83	**196**
03.VIII.2014	30	58	**146**	18	200	**218**
15.VIII.2014	84	30	**144**	12	226	**238**
29.VIII.2014	139		**139**		225	**225**
29.IX.2014	130		**130**		210	**210**
14.X.2014	117		**117**		193	**193**
25.V.2015	73	4	**81**	4		**4**
20.VI.2015	135	58	**251**	185		**185**
30.VI.2015	46	104	**254**	42	184	**226**
11.VII.2015	177	41	**259**	55	246	**301**
21.VII.2015	45	108	**261**	40	264	**304**
02.VIII.2015	172	38	**248**	15	283	**298**
15.VIII.2015	206	19	**244**	18	277	**295**

Table 1. Observations of *Podiceps nigricollis* during 2014 and 2015 breeding seasons in the "Lago di Pergusa" (Sicily, Italy).



Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2004	🟦 6	🟦 5	🟥 10	🟥	🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟦
2005	🟦	🟦	🟥	🟥	🟨 1	🟨 1	🟨	🟨 1	🟥 1	🟥	🟥	🟦
2006	🟦	🟦 2	🟥	🟥 1	🟨 4	🟨 2	🟨	🟨 3	🟥 2	🟥 1	🟥	🟦
2007	🟦 1	🟦	🟥	🟥 5	🟨 5	🟨 10	🟨 5	🟨	🟥 3	🟥	🟥	🟦
2008	🟦 4	🟦 2	🟥 2	🟥 2	🟨 6	🟨	🟨 4	🟨 3	🟥	🟥	🟥	🟦 4
2009	🟦 2	🟦	🟥	🟥	🟨	🟨	🟨	🟨 6	🟥 12	🟥 12	🟥 8	🟦 5
2010	🟦 4	🟦 4	🟥	🟪	🟪 2	🟪 6	🟪 14	🟧 16	🟧 15	🟧 15	🟥 6	🟦 2
2011	🟦 2	🟦 4	🟥 6	🟥 8	🟨 8	🟨 8	🟨 4	🟨 2	🟥 2	🟥	🟥 5	🟦 3
2012	🟦 8	🟦 8	🟥 15	🟪 20	🟪 40	🟪 50	🟪 50	🟧 45	🟧 46	🟧 45	🟥 12	🟦 4
2013	🟦 5	🟦 5	🟥 10	🟪 18	🟪 41	🟪 81	🟪 128	🟧 124	🟧 120	🟧 120	🟥 10	🟦 8
2014	🟦 12	🟦 12	🟥 28	🟪 48	🟪 67	🟪 99	🟪 142	🟧 146	🟧 130	🟧 117	🟥 28	🟦 12
2015	🟦 23	🟦 25	🟥 32	🟪 56	🟪 81	🟪 254	🟪 261	🟧 248				

🟦 Wintering
🟥 Migration
🟨 Summer presence (not breeding)
🟪 Breeding season
🟧 Post-breeding season

Table 2. Maximum number of adults of *Podiceps nigricollis* observed in the different months (2004–2015) in the "Lago di Pergusa" (Sicily, Italy).

cannot be distinguished as the adults turn into the winter plumage.

On the Lake, the number of individuals is markedly reduced starting in November; the occurrence of *P. nigricollis* in wintering is much reduced: in the 2010–11 winter there were 2–4 observed individuals, in the 2011-12 winter 3–8, in the 2012–13 winter 4–5 (Termine & Massa, 2015); in the 2013–14 winter 8–12, and in the 2014–15 winter 12–25 (Table 2).

During the breeding season, including the one in 2010, in the Lake there was a marked water vegetation cover forming floating mats, probably promoting the occurrence and breeding of this species.

CONCLUSIONS

We therefore emphasise the importance of this protected natural area as a breeding site for the *Podiceps nigricollis*. The restored ecological and conservation conditions of the Lake may have favoured an optimal context for this species settlement.

This Lake has so far counted the largest number of breeding pairs for Sicily and Italy (Verducci & Sighele, 2013).

Monitoring of avifauna is fundamental for understanding the evolution of biotic elements of the ecosystems; in fact the avian populations change according to diverse and often fast paces, therefore the continuous monitoring is crucial for assessing the conservation status of protected natural areas, including the ones in Rete Natura 2000, given the significant effect of biotic and abiotic variables on the breeding success.

In Italy the low number of nesting sites make this breeding population particularly vulnerable to environmental fluctuations and the action of other disturbance elements even at small scales (Gustin et al. 2010). Accordingly, in addition to population monitoring, it is necessary to at least continue to monitor the water quality so that to prevent potential negative effects on the whole community.

Given its rare status as a breeder species, the Black-necked Grebe is a species understudied in Italy (Gustin et al., 2010) so that sessions of banding and marking are strongly warranted.

Finally, given the exceptional nature of breeding occurrence of the this species in Italy, investigating the winter movements of young with tracking devices would warrant future investigations as this event appears to become consistent across the years.

ACKNOWLEDGMENT

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Biodiversity Journal, 2017, 8 (1): 119–121

MONOGRAPH

Mycterodus arpadi Dlabola, 1977 (Hemiptera Issidae): a new record from Europe

Ilia Gjonov

Sofia University “St. Kliment Ohridski”, Faculty of Biology, Department of Zoology and Anthropology National Museum of Natural History, Sofia, Bulgaria; e-mail: gjonov@cicadina.com

ABSTRACT *Mycterodus arpadi* Dlabola, 1977 (Hemiptera Issidae) is reported only from Asia Minor (Beikoz, Istanbul Province). In 2012, in the Bulgarian part of the Strandzha Mountain a few specimens of the species were collected and photographed. This is the first record of *M. arpadi* in Europe.

KEY WORDS Bulgaria; fauna; Issidae; *Mycterodus arpadi*; new record.

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INTRODUCTION

The Issidae family described by Spinola in 1839, belongs to the order Hemiptera and includes numerous species. In the Western Palaearctic there is only one tribe, Issini Spinola, 1839 comprising 51 genera and more than 455 species (Gnezdilov, 2013).

The genus *Mycterodus* Spinola, 1839 is one of the richest within the family. It is present in the Western Palaearctic with 40 species distributed in Central and Southeastern Europe, Eastern Mediterranean Basin, Anatolia, Caucasus, Middle Asia, and Iran (Gnezdilov et al., 2014).

Mycterodus arpadi Dlabola, 1977 was described on the base of only one male specimen from Beikoz (the Anatolian part of Turkey). The specimen is deposited in the Hungarian Natural History Museum (Budapest) (Dlabola, 1977). There are no other published records except the holotype. Nevertheless, four specimens are included in the collection of the National Museum of Natural History in Paris (Mike Wilson, pers. comm.). In the Turkish literature the species is treated as endemic (Lodos & Kalkandelen, 1981; Önder et al., 2011). The species is assigned to the subgenus *Mycterodus* s. str. (Dlabola, 1995; Gnezdilov et al., 2014).

Two other species of *Mycterodus* are reported from Bulgaria - *M. cuniceps* Melichar, 1906 and *M. immaculatus* Fabricius, 1794. According to Gnezdilov et al. (2014) the records concerning *M. immaculatus* need a revision. Gruev (1970) described another species - *M. longivertex* - but 3 years later the author referred to the species as a junior synonym of *M. cuniceps* (Gruev, 1973).

Mycterodus usually live on bushes and small trees. *M. cuniceps* is frequently collected on oaks.

This is the first record of *M. arpadi* for Europe.

MATERIAL AND METHODS

EXAMINED MATERIAL. Bulgaria, Strandzha Mt., Popovi skali, N 42.1630 E 27.7373, 52 m a.s.l., 1 male 2 females, 10.V.2012, m = 20/12, leg. I. Gjonov (Figs. 1, 2).

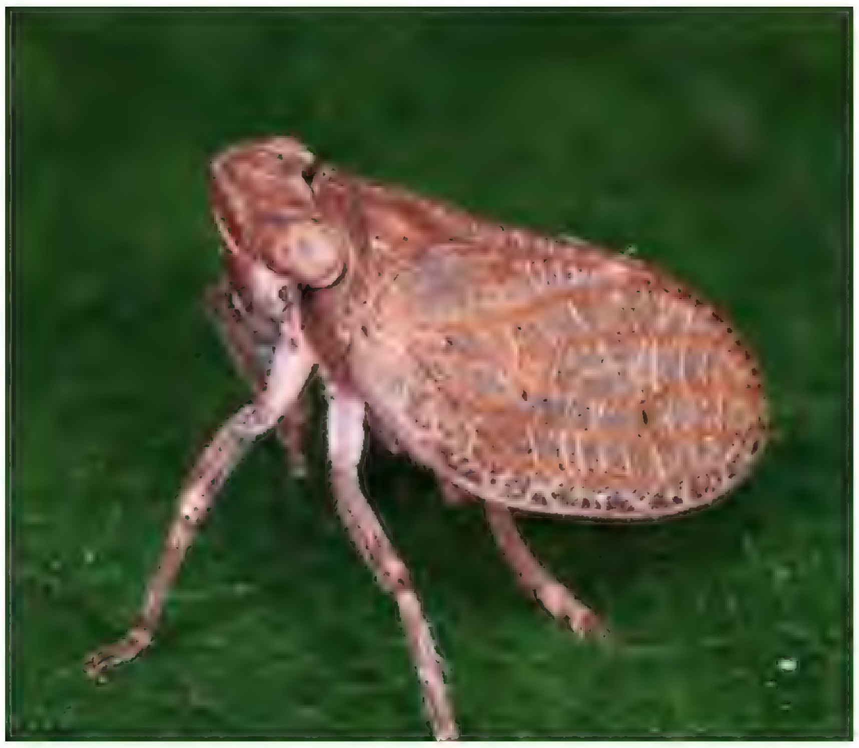

Figure 1. *Mycterodus arpadi* lateral view.

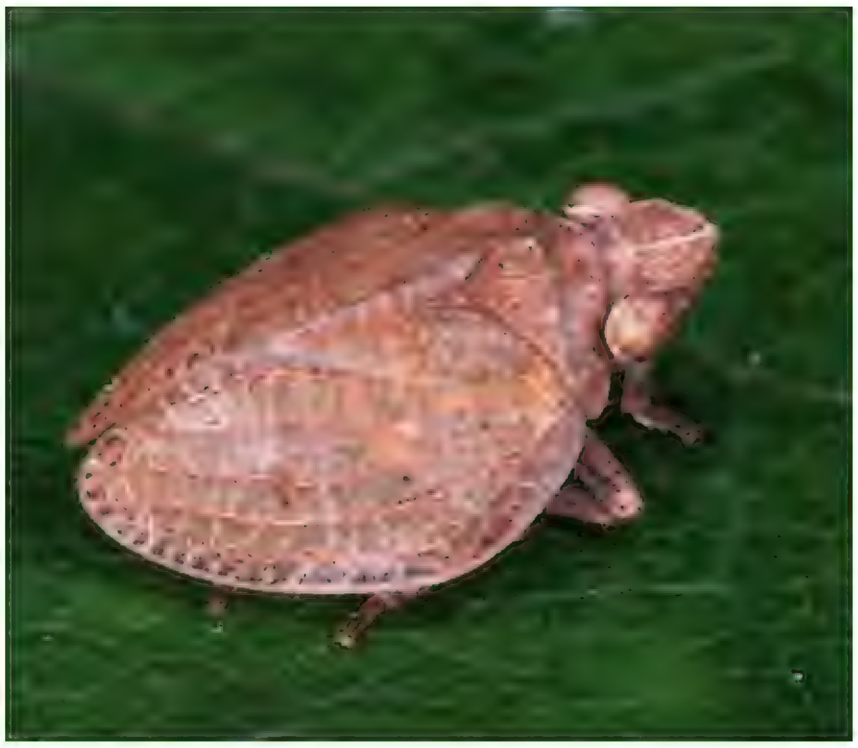

Figure 2. *Mycterodus arpadi* dorsal view.

The material was collected by entomological sweeping net in May 2012 in the Bulgarian part of the Strandzha Mountain. The location is not far from the Black sea coast in a limestone area with bushy slopes, close to a small river. The specimens were collected on oaks. Photographs of the living specimens were taken by Olympus E-500 DSLR camera with Sigma 150mm F2.8 EX DG OS HSM APO Macro lens with Raynox DCR-250 macro lens and ring flash. After photographing the samples were stored. The specimens were preserved dry; thei were identified by examining external morphology and by carrying out a detailed examination of genitalia following the original description (Dlabola, 1977).

RESULTS

Photos of the genital structures made under microscope were sent to András Orosz in HNHM, Budapest, and he compared them with the genital of the holotype and confirmed the species identification.

DISCUSSION AND CONCLUSIONS

Till now *M. arpadi* was known as an Anatolian endemic species. Considering the lack of previous data, *M. arpadi* could be regarded as a rare species. With this record the knowledge on the distribution of *M. arpadi* is expanded and new data about the composition of the family Issidae in Bulgaria are added.

ACKNOWLEDGMENTS

I am grateful to András Orosz, HNHM, Budapest, for confirming species identification and to Mike Wilson, National Museum Cardiff who kindly provided essential information.

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Biodiversity Journal, 2017, 8 (1): 123–144 **MONOGRAPH**

Review of the observations of aggregates of Steninae reported since 1856 (Coleoptera Staphylinidae)

Giulio Cuccodoro

Muséum d'histoire naturelle, C. P. 6434, CH-1211 Genève 6, Switzerland; e-mail: gulio.cuccodoro@ville-ge.ch

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ABSTRACT The nine aggregates of Steninae documented since 1856 are reviewed, completed with seventeen new reports. All the pictures available on the topic are presented. Considering the ubiquity and megadiversity of the subfamily, this total of 26 observations reported over the last 150 years appears strikingly low, clearly indicating that the phenomenom is exceptional. These observations were all made in the Palaearctic and Oriental realms, and refer to both the extant genera of Steninae *Dianous* and *Stenus*. Six observations refer to *Dianous* species, all from China, mainly *D. banghaasi* and *D. freyi*. Of the twenty observations referring to *Stenus* ten were made in the Mediterranean area, mainly on *S. cordatus*, *S. elegans* and *S. turk*. This collection of observations seems a composite of several kinds of behavioural patterns, such as hibernation, aestivation, reproductive swarming, and possibly hilltopping, with some most likely intermixed. Aggregation in compact multilayer masses of individuals as well as occasional recurrence of *Stenus* aggretates at precise locations over days or year are probably controlled by pheromone signals. The reasons driving these slender, one centimeter long rove beetles to occasionally swarm in compact masses of well over hundred thousand individuals remain nevertheless as enygmatic as how such a spectacular phenomenom performed by members of the second most diverse genus of animals on earth can remain so rarely observed.

KEY WORDS Ethology; aggregation; behaviour; reproduction; hilltopping; Mediterranean Region.

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INTRODUCTION

Steninae are very distinctive slender rove beetles with broad globular compound eyes. The subfamily is distributed virtually worlwide except Antarctica and New Zealand. It consists of some 2750 extant species grouped in the genera *Dianous* Leach, 1819 and *Stenus* Latreille, 1779, the latter being the second most diverse genus of animals with approximately 2550 species (Herman, 2001; Thayer, 2005; Cai et al., 2014). Feeding essentially on collembola *Stenus* possess a chameleon-like protrusive prey-capture mouth apparatus unique within insects, which is probably the key innovation responsible for the impressive radiation of the group (Betz, 1996, 1998). Partly because of the marked attraction of their favoured preys for humid microhabitas, Steninae are mainly found in moist forest leaf litter, near swamps, along river banks or lake shores, but also walking on the foliage of tropical rainforests. In Europe their greatest diversity is to find in moist environments such as reeds, where some species forage on humus or plants debris near the ground, while others prefer to climb on plants, or are surface runners on bare ground (Betz, 1999a, 1999b). Although they usually possess fully functional wings, they all are very reluctant to flight, and move almost only walking or running. Hence another of their evolutionary traits appears to be a trend towards significant widening of tarsi, resulting in the apparently repeated emergence of water-gliding and swimming habilities (Betz, 2002).

In 2005 I was casually confronted to another striking pecularity of Steninae unique within rove-beetles, which is their ability to occasionally congregate in very large numbers and form dense multilayer masses of individuals (Cuccodoro, 2007; Puthz, 2008). Submitting my few pictures and field notes to the *Stenus* specialist Volker Puthz, I was very suprized to learn that such an impressive phenonenom was still documented in the literature with only a handfull of short notes since first reported some 150 years ago from France (Dufour & Perez, 1857).

Here I review the nine observations of aggregates of Steninae recorded hitherto in the litterature (Dufour & Perez, 1857; Rougemont, 1980; Abdul-Nour & Kallab, 1989; Lecoq, 1991, 1993; Cooter, 1997; Puthz, 2000; Zhao & Li, 2004; Cuccodoro, 2007), as well as sixteen additional observations reported to me by colleagues, or gathered over the internet. All the pictures available to me are presented, with some pertaining to previous records published here for the first time. The structure of these observations as well as possible causes and adaptative interests of the phenomenom are briefly discussed. Hopefully this will stimulate investigations on this phenonomenom, which is definitely as spectacular as it remains enygmatic.

MATERIAL AND METHODS

Most unpublished observations were forwarded to me by Volker Puthz, Schlitz. He obtained them mainly in feedback to his repeated call for informations on the topic "Stenus-*Ansammlungen im Mittelmeerraum: wer hat solche Massenvorkommen von Stenus (Staphylinidae) auf einer kleine Fläche (unter Stein, o. ä.) beobachtet? Mitteilung Dr. V. Puthz (….)*" [*Stenus* - aggregations in the Mediterranean area: who observed such mass occurences of Stenus (Staphylinidae) on a small surface (under *stone, or similar)?* Contact Dr. V. Puthz] published in the rubric Von Kollege zu Kollege on the recto of the backcover of volumes 73 (1977) to 77 (1981) of the journal Entomologishe Blätter. Several unpublished observations were also forwarded to me by the other specialists of Steninae Guillaume de Rougemont, London, and Liang Tang, Shanghai. The rest was addressed to me in feedback to my presentation on the topic at the "22nd International Meeting on Biology and Systematics of Staphylinidae" in Stuttgart (Cuccodoro, 2007) and to my call for informations addressed in June 2011 to all the email list of the announcement of 26th edition of the same meeting, or gathered by myself over the internet. When still possible I also contacted the authors of previously published reports for additional informations.

RESULTS

The observations of aggregates of Steninae are listed below organized chronologically, and consequently numbered.

1) September 1856, Saint Sever (France)

The first observation of an aggregate of Steninae was made near Saint Sever (Landes France) in the beginning of September by a local teacher named Perez (first name unknown). He brought back to Léon Dufour for identification a sample containing two thousands and several hundreds of individuals of *Stenus rusticus* Erichson, 1840 (= *Stenus picipes* Stephens, 1833), which were only a fraction of those forming the aggregate he witnessed. Curious to see the phenomenom by himself L. Dufour went there some days later with M. Perez, and they could observe it again exactly at the same place. It was on leaves of a chestnut stump cut at level with the ground located on the edge of a small, dry ravine. The leaves were completely blackened by the beetles piled one on each other. He estimated that they were more that twenty thousands individuals within an area of 50 cm in diameter. Dufour shaked the leaves and heard "like a rain of sand", so he put his hand underneath, which was readily filled with thousands of *Stenus*. These were etherized, put into a glass vial and given to his friend Joseph Alexandre Laboulbène, with charge to present that sample together with a report of the observation at the Entomological Society of France in Paris. It was finally Léon Fairmaire, in the name of Laboulbène, who read the note of Dufour at the 22 October 1956 meeting of the Entomological Society of France (Dufour & Perez, 1857).

Note. The note is referred to as "Stenus rusticus *rencontré en immense quantité (note sur le), L. Dufour et Perez*" in the table of contents (alphabetical by taxa) at page CLXIV of tome IV of the Annales de la Société Entomologique de France (3rd series), in the section containing the reports the meetings of this society in the last trimester of 1856; as the last meeting reported was on 24 December 1856, it is very unlikely that the volume was published before the end of that year, hence my quotation of the reference not following Lecoq (1993), who credited the publication of the note to Fairmaire in 1856.

2) 12 June 1972, Rosas (Spain) - Figs. 1, 2

The aggregate was observed by Alfred Elbert in montains West of Rosas (Catalogna, Spain). It occurred under a large stone, and consisted of several thousands individuals of *Stenus* sp. massed in a few multilayer masses (Figs. 1, 2). Reported to V. Puthz by A. Elbert in January 1973 (V. Puthz pers. comm.).

3) 12 July 1972, Tchirtchik (Uzbekistan)

The aggregate was observed by Josef Král some 1,000-1,300 m above sea level in the Aktesch Valley near Tchirtchik in the western part of the Mts. Tienshan (Tschaktall ridge), some 50 km West of Taschkent (Uzbekistan). The Aktesh Valley is North oriented, and the place was located at base of a rocky cliff, quite humid with many stones and plants, probably occasionally flooded. Turning a 25x15 cm stone was found a 6x4 cm mass affixed to it and consisting exclusively of *Stenus* facing the edge of the stone, organized in several layers with their abdomens oriented regularly, resembling roots. Some individuals were collected using an aspirator, but as the others started to quit the mass and run away, the stone was put in a sifter in order to catch them all. No particular smell, taste, or any other inconvenience was experienced during the process. This sample totalized 1,217 specimens of *Stenus turk* Puthz, 1972 with a sex ration of 36 females for 64 males in a random sample of 100 individuals (det. L. Hromádka). Additional masses were found under some other stones, thought only those located at a few steps of the first one, as well as in a few shadowed and wet places at base of the cliff. Reported to V. Puthz by J. Král in August 1976 (V. Puthz pers. comm.).

4) 29 September 1972, Kreta (Greece)

The aggregate was observed by Hans Malicky in the Yeropotamos river valley near the bridge below Phaistos palace (Kreta, Greece). It occurred in the late afternoon of a sunny day in a place already at shade, and consisted of more than 10,000 individuals of *Stenus picipes* (det. V. Puthz) aggregated in compact clusters hanging on a few blades of grasses near the river shore, from far looking like bee swarms. There were no stones in the area. Reported to V. Puthz by H. Malicky in August 1977 (V. Puthz pers. comm.).

5) 3 July 1977, Trimiklini (Cyprus)

The aggregate was observed by Stanislav Vit near the village of Trimiklini on the island of Cyprus. It occurred in the late morging of a sunny day on the bank of a stream in a small ravine shadowed by a gallery forest, and consisted of several thousands of *Stenus turbulentus* Bondroit, 1912 running around on only a few square meters along the steam shore, but he didn't noticed any dense multilayer masses of individuals. Reported to me by S. Vit in June 2011.

6) January 1979, Kathmandu (Nepal)

The aggregate was observed by Guillaume de Rougemont near the Dakshinkali Temple (Kathmandu, Nepal). The aggregate was estimated to consist of over 50 individuals of *Stenus immsi* Bernhauer, 1915 massed closely under a loose boulder on the bank of a stream. Frost prevailed at night. Individuals remained inactive when disturbed, apparently in state of hibernation, in sharp contrast with the activity of other specimens collected few months before in October in litter at roots of plants near a small torrent. Reported in Rougemont (1980).

7) 1981, Aurès (Algeria)

The aggregate was observed by Jean-Michel Maldes and Serge Doguet on Djebel Mamel (Aurès, Algeria). It occurred in a deep and shadowed crack of a big rock, and was estimated to consist of several thousands individuals of *Stenus cordatus* Gravenhorst, 1802. Nearby was also observed an aggregate of Chalcoidea. Reported in Lecoq (1993).

8) 31 August 1981, Corfu (Greece)

The aggregate was observed by Gerhard Katschak along the Ropa river on the island of Corfu (Greece). It occurred at around noon on a quite humid and 26 °C warm sunny day. In the bed of the river, which is reduced to puddled at this time of the year, were several thousands individuals of *Stenus* sp. gathered on only a few square meters close to some puddles, most quite active walking around on the ground. Sampled specimens pertained to six species: *S. hospes* Erichson 1840, *S. indifferens* Puthz, 1967, *S. pallitarsis* Stephens, 1833, *S. planifrons* Rey, 1884, *S. similis* (Herbst 1784), and *S. sinuatus* Cameron, 1930, with approximately 70% of them being *S. pallitarsis* and *S. planifrons*; sex ratio balanced. Reported to V. Puthz by G. Katschak in September and October 1981 (V. Puthz pers. comm.).

9) 27 May 1983, Tilos (Greece)

The aggregate was observed by Dieter Liebegott near the cloister of Agios Panteleimon on the island of Tilos (Greece), nearby the aggregate of Apion reported by Liebegott (1983). It occurred on a sunny day at noon along a small creek, and consisted of several thousands individuals of *Stenus* sp. densely grouped under some stones on a few square meters. The beetles were motionless, and massed to a depth of 2–3 bodies in the middle each group. Reported to V. Puthz by D. Liebegott in June 1983 (V. Puthz pers. comm.).

10) 27 June 1987: San Pietro Island (Italy) - Figs. 3, 4

The aggregate was observed by Maurizio Mai and Roberto Poggi at an elevation of 140 meters above see level on the westen slope of the Monte Guardia dei Mori (Fig. 3). It occurred under decaying leaves in the stony bed of a dry stream. The aggregate consisted of about 700 individuals of *Stenus* sp. intermixed with approximately an equal number of *Apion* sp., all forming one dense aggregate covering only few squares centimeters. Individuals were motionless, apparently inactive. About half of the individuals were sampled (Fig. 4), totalizing 358 *Apion* (s. str.) *gracilicolle* (Gyllenhal, 1839) and 375 *Stenus* (*Parastenus*) *elegans* Rosenhauer, 1856. Reported in Lecoq (1993); additional informations and pictures sent to me by R. Poggi in July 2011.

11) June 1988, Cave Mgharet el Qlanssiyé (Lebanon) - Figs. 5, 6

The aggregate was observed by Hani Abdul-Nour, Nayla Abdul-Nour, Malaké Assouad, Fadi VBaroudi, Antoine Ghaouche, Oussama Kallab, and Paul Khawaja in the cave Mgharet el Qlanssiyé located at base of a small cliff close to a small tributary of the ouedi Qozhaïa, only few kilometres away from Kfar Sghab (Lebanon). It occurred on the ceiling of the cave at some five meters from its entrance (Fig. 5). On an area of ten square meters were some fifteen dense, black masses of *Stenus*, each several centimeters thick, with some isolated individuals walking between, for an estimated total of more than 100,000 individuals. The mass on figure 6 covered an area of about 200 cm^2 and was estimated to contain between 10,000 and 30,000 individuals. Amazingly some spiders were affixed with silk threads above some groups of *Stenus* sp., motionless, becoming suddenly very aggressive when approaching the hand, as if defending their larder. Specimens sampled were *Stenus cyaneus* Baudi, 1848. Reported in Abdul-Nour & Kallab (1989); original colour dia of Fig. 6 and specimens sent to me by H. Abdul-Nour in October 2007.

12) July 1988, Pyrénées orientales (France)

The aggregate was observed by Jean-Claude

Lecoq at some 1200 m above sea level close to the top of Pic Néoulou (Pyrénées orientales, France). It occurred under a 30x40 isolated stone lying on wet grass close to the tree line, and consisted of several thousands individuals densily grouped on an area large as two hands. Individuals were nearly motionless. Specimens sampled were *Stenus cordatus*; sex ration balanced. According to his experience the species is not very common in the area, and individuals were kilometers away of their nearest favorite habitat. Reported in Lecoq (1991).

13) 1994, Sichuan (China)

The aggregate was observed by Fa-Ke Zheng on the Emeishan in Sichuan (China), and consisted of several thousands *Dianous freyi* Benick, 1940 gathered in dense multilayer masses on and under a large boulder near a stream. Reported in Puthz (2000).

14) May 1996, Zhejiang (China)

The aggregate was observed by John Cooter in the Long Wang Shan Nature Reserve (Zhejiang, China), and consisted of several thousands *Dianous freyi* in a deep horizontal crevice under a huge boulder resting on bare rock on the bank of a stream. They were near motionless in the deep shade, forming a continuous mass 1–2 cm deep and 3–5 cm across, and extending for well over one meter. Nearby specimens of *D. banghaasi* Berhnauer, 1916 were active at the sun on the bare rock, while individuals of *D. freyi* would actively seek shelter in shallow crevice or under dead leaves when disturbed. Reported in Cooter (1997).

15) 2 June 1999, Sardegna (Italy)

The aggregate was observed by Roberto Poggi at some 1000 meters above sea level nearby Genna Silana at Fonte Esilai (Sardegna, Italy). It occurred near a stream, and consisted of several hundreds individuals of *Stenus* sp. very densely grouped together. Specimens sampled pertained to two species: *S. cordatus* and *S. elegans*. Reported to me by R. Poggi in July 2011.

16) 16 August 2000, Guangdong (China) - Figs. 7, 8

The aggregate was observed by Graham T. Reels in the Chebaling Nature Reserve (Guangdong, China). It occurred by a stream in subtropical forest, and consisted of several thousands *Dianous* sp. densely massed in four separate groups near the base of a single very large boulder (Fig. 7). All the beetles were motionless, and massed to a depth of 4–5 bodies in each group (Fig. 8). A sample from two of the masses made by scooping an open tube through the beetles included about 250 individuals of *D. banghaasi*, and a single individual of an undescribed species. Reported to G. de Rougemont by G.T. Reels in September 2000 (G. de Rougemont pers. comm.).

17) May 2003, Zhejiang (China)

The aggregate was observed by Liang Tang and Li-Zhen Li some 300 meters above see level on Mt.Tianmushan (Zhejiang, China). It occurred during a cloudy day on the boulders of a big steam, and consisted of several hundreds *D. banghaasi* and *D. freyi* densely grouped on each other on a few square centimeters close to the water surface. Reported with a picture in Zhao & Li (2004); additional informations reported to me by L. Tang in June 2011.

18) 25 July 2003, Guizhou (China)

The aggregate was observed by Liang Tang at 700 meters above see level on Mt. Fanjingshan (Guizhou, China). It occurred during a sunny day on a boulder in a big steam, and consisted of about hundred *Dianous* sp. pertaining to two distinct species with red elytral spots, individuals densely grouped on each other on a few square centimeters. Reported to me by L. Tang in June 2011.

19) 2004, Nanchong (China)

The aggregate was observed by Fa-Ke Zheng in Nanchong (China). It occurred on a boulder close to a stream, and consisted of large numbers of *D. banghaasi* (not *D. freyi,* G. de Rougemont pers. comm.) on a very small area. Reported in Zhao & Li (2004).

20) 17 and 19 October 2005, Mt Barail (India) - Figs. 9–15

The aggregate was observed by Alessandro Marletta and me near the town of Haflong (North Cachar Hills) in the cloud forest located at the top of the 1800 m high Mt. Barail (Assam, India) (Fig. 10). It occurred at the edge of the summital clearing (Fig. 9), and consisted of more than five thousands individuals densely concentrated at base of a small tree.

We discovered the aggregate in the early afternoon of a rather cloudy day. Individuals were almost everywhere up to 1.5 m high on the mossy stem (Fig. 11), as well scattered at a few centimeters from each other almost everywhere over the surrounding couple of square meters of vegetation (Fig. 13, 14). Density of individuals was particularly high underneath some recurved dead broadleaves and in shallow cavities of thin dead branches, where they formed compact multilayer masses (Fig. 12). Most individuals appeared moderately active, with many couples *in copula* (Fig. 14). Specimens sampled were all *Stenus stigmatias* Puthz, 2008; sex ration balanced. The aggregate was still going on when we left the place at 3.30 PM. The following morning we returned there and settled our camp for further investigations, but couldn't find even a single *Stenus*, and rain started pooring on us from 3 PM until late in the night. The day after was sunny until clouds obscured the sun from late morning throughout the afternoon. At about 1 PM we suddenly noticed again some *Stenus* near the same particular tree. As if they were oosing out of its trunk and basal branches (Fig. 12), their number increased dramatically and within half an hour the aggregate had resumed with the same intensity as two days before. At around 4 PM, the attendants at the aggregate appeared to have significantly decreased in number, and they were all gone before sunset a 4h30 PM. I returned and camped there at the same period of the year during two weeks in 2006 and one week in 2008, but couldn't see again even one individual of *S. stigmatias*. Reported in Cuccodoro (2007) and Puthz (2008).

21) September–November 2005–2009, Montefiascone (Italy) - Figs. 15–19

The aggregate was observed by Anonymous in the village of Montefiascone, located on a small rocky hill two kilometers away from the eastern shore of lake Bolsena (Latium, Italy) (Fig. 15). It occurred inside a refurnished part of a very ancient house and its underground cellar (Fig. 16, 17), both adjoining to the thousand years old castel erected on top of that 620 m high local summit. Consisting of more than hundred thousands individuals, the phenomenom lasted several weeks typically from late September to late November, and reoccurred annually at least from 2005 to 2008. It was so intrusive that the owner of the house and his family moved out during that period of the year. Despite intensive efforts to seal every possible entrance into the house (mosquito nets at windows, joining around the door and windows frames, etc.) the owner never succeeded to prevent the *Stenus* sp. from coming, and then going out. He never saw them flying. Amazingly individuals tended to concentrate in dark places (angles of the rooms, under the furnitures, etc., Fig. 18), but they were moving rather toward the windows while aggregated. During these seasonal invasions individuals were seen mating (Fig. 19), and only very few dead specimens were left behind after leaving. The phenomenom never occurred elsewhere in the neighborhood, and stopped after heavy sanitation works were carried out in and around the house in Spring 2009. Reported on the WEB (Forum Entomologi Italiani) by Anonymous in March 2009; further informations reported to me by Anonymous in March 2009.

22) June 2009, Hainan Island (China)

The aggregate was observed by Anonymous in Yingeling Nature Reserve (Hainan Island China). It occurred on leaf litter in forest near the mountain summit, and consisted of several thousands *Stenus* sp. pertaining to at least two species (one black with red spots and the other bluish black) intermixed on a very small area. Reported to me by L. Tang in June 2011.

23) 9 September 2010, Komirshi river (Kazakhstan) - Figs. 20–23

The aggregate was observed by Vitaly Katscheev in the gorge of river Komirshi (Kyrgiz Alatau, Kazakhstan, Fig. 20), and consisted of more than four hundred individuals of *Stenus turk* forming a continuous congestion on a 20x30 cm platform under a willow bush close to a stream (Figs. 21–23). Only individual specimens were found nearby, with an average density of 18.7 individuals per square meter on the 10 square meters around this bush. Reported to V. Puthz by V. Katscheev in January 2011 (V. Puthz pers. comm.).

24) 13 May 2011, Mt. San Angelo (Italy)

The aggregate was observed by Pavel Krásenský at an elevation of 815 m above sea level on the North slope of Mt. Saint Angelo (Apulia, Italy) during a sunny day with about 15 °C at shadow, and no wind. It occurred near the entrance of a small cave located - 41°42'36.1"N 15°56'33.8"E - in a sheltered depression in oak forest, and consisted of about 200 to 300 *Stenus cordatus* scattered on the grass on an area of about ten square meters completely at shade. The specimens quickly ran on the grass, and about half of them flown. After about 15 minutes of observation the specimens slowly disappeared. Reported to me by P. Krásenský in February 2016.

25) 22 November 2014, Virajpet (India) - Figs. 24–28

The aggregate was observed by Vipin Baliga and A.K. Karthik near Virajpet (Karnataka, India). It occurred in a sheltered depression on the vertical face of a huge boulder adjacent to a stream, and consisted of several thousands of *Stenus* sp. grouped in two dense masses (Figs. 24, 25). As they were taking pictures, they noticed that individuals were slowly dispersing, moving away from the groups (Figs. 26–28). After a few pictures they went ahead and while returning found them scattered over a greater area. Despite my efforts I couldn't spot a couple *in copula* in the close up pictures of the aggregate (Figs. 26, 27). Reported on the WEB (India Biodiversity Portal) by V. Balinga in December 2014; further informations reported to me by V. Balinga in February 2017.

26) 5 February 2015, Agumbe (India) - Figs. 29–33

The aggregate was observed by Lukáš Podloucký at some 100 meters above see level near the Onake Abbi falls at Agumbe (Karnataka, India). It occurred at around 2 PM of a 30-35 °C hot sunny day on the stem of tree shaded by branches close to a stream (Fig. 29). Estimated to consist of more than hundred thousand individuals densily grouped in one multilayer mass it is by far the largest *Stenus* aggregate ever photographed (Figs. 30-33). The mass did not change shape, nor moved during the quarter of an hour it was surveyed. Only after small disturbation (blow, touch, ...) some individuals tried to escape from the shape of the mass, and some of the tree. Despite my efforts I couldn't spot a couple *in copula* in the close up pictures of the aggregate (Figs. 32, 33). Reported on the WEB (Friends of Coleoptera Entomology department Facebook page) by J. Kadlec in December 2015; further informations reported to me by L. Podloucký in December 2015.

DISCUSSION AND CONCLUSIONS

This collection is very heterogeneous, and at first glance quite puzzling. It seems in fact that this assemblage deals with different kinds of phenomena, with some of them probably even mixed up. So at this level of knowledge (rather of ignorance) it would be certainly very hazardous to draw any definitive interpretation to most of them. However some considerations can nevertheless be made.

First both the genera *Dianous* and *Stenus* are involved. And some species are more frequently cited, notably *S. cordatus* (reports 1, 12, 15 and 24), *S. elegans* (reports 10 and 15), and *S. turk* (reports 3 and 23), and *D. banghaasi* (reports 16, 17 and 19) and *D. freyi* (reports 13, 14, 17). More frequent aggretative behaviour in these taxa might reflect either a higher sensibilty to drought of these two *Dianous* species inhabiting in subtropical climate, or in the contrary a better adaptation precisely to long periods of draught of these three *Stenus* species inhabiting in the Mediterranean climate.

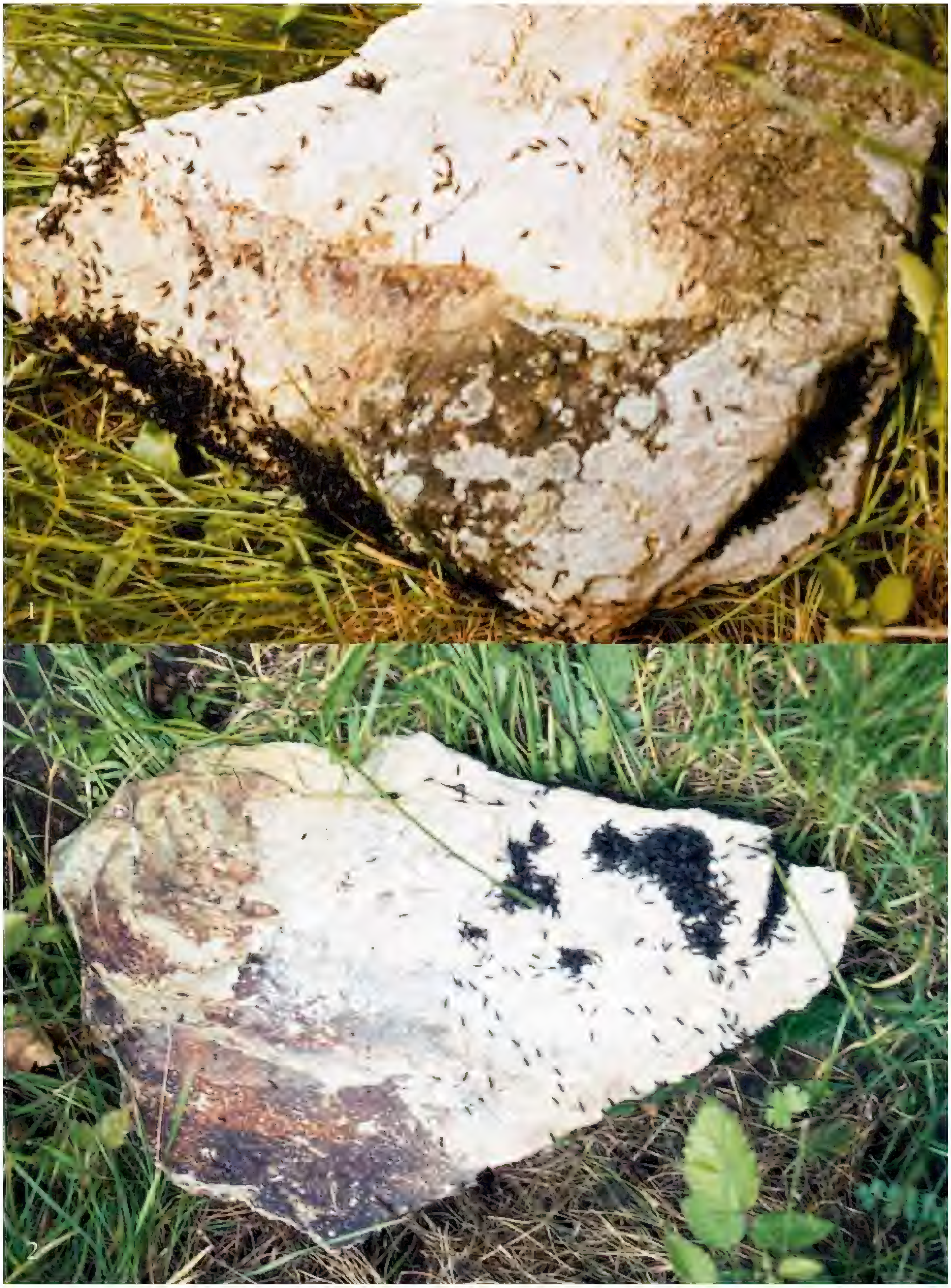
However considering the megadiversity and ubiquity of the subfamily, in particular of the genus *Stenus*, and in the light of the repeated calls for observations on the topic made since 1977 it is quite astonishing that the new total of reports since 1856 is of twenty six only. Many staphylinists who spent years of their life in cumulate fieldwork throughout the world never had the chance to witness a *Stenus* aggregate. And for the few lucky ones it mostly remained a once in a lifetime experience to which they were unprepared, hence the scarcity of the pictures made. Fortunately the phenomenom is truly so impressive that it stroke the attention even of non-specialists, to whom we owe the best and most impressive pictures available (Figs. 24–33). This indicates clearly that even if possibly common in some stenine taxa, aggregative behaviour certainly remains very exceptional within the subfamily.

Generaly speaking it is not so uncommun to find Steninae concentrated in high population density in some peculiar suitable biotopes. For example sometimes hundreds, or even thousands individuals of *Stenus* may inhabit mossy spots over rocky slope, and assemblages of several species of *Dianous* can also rather frequently be seen by dozens feeding at base of some particular boulders in streams. Nevertheless those specimens are always separated one from another with some distance, doing their own business apparently without communicating with each other. This could well be the case for the reports 5 and 8, the later consisting of a congregation of six different species of *Stenus*.

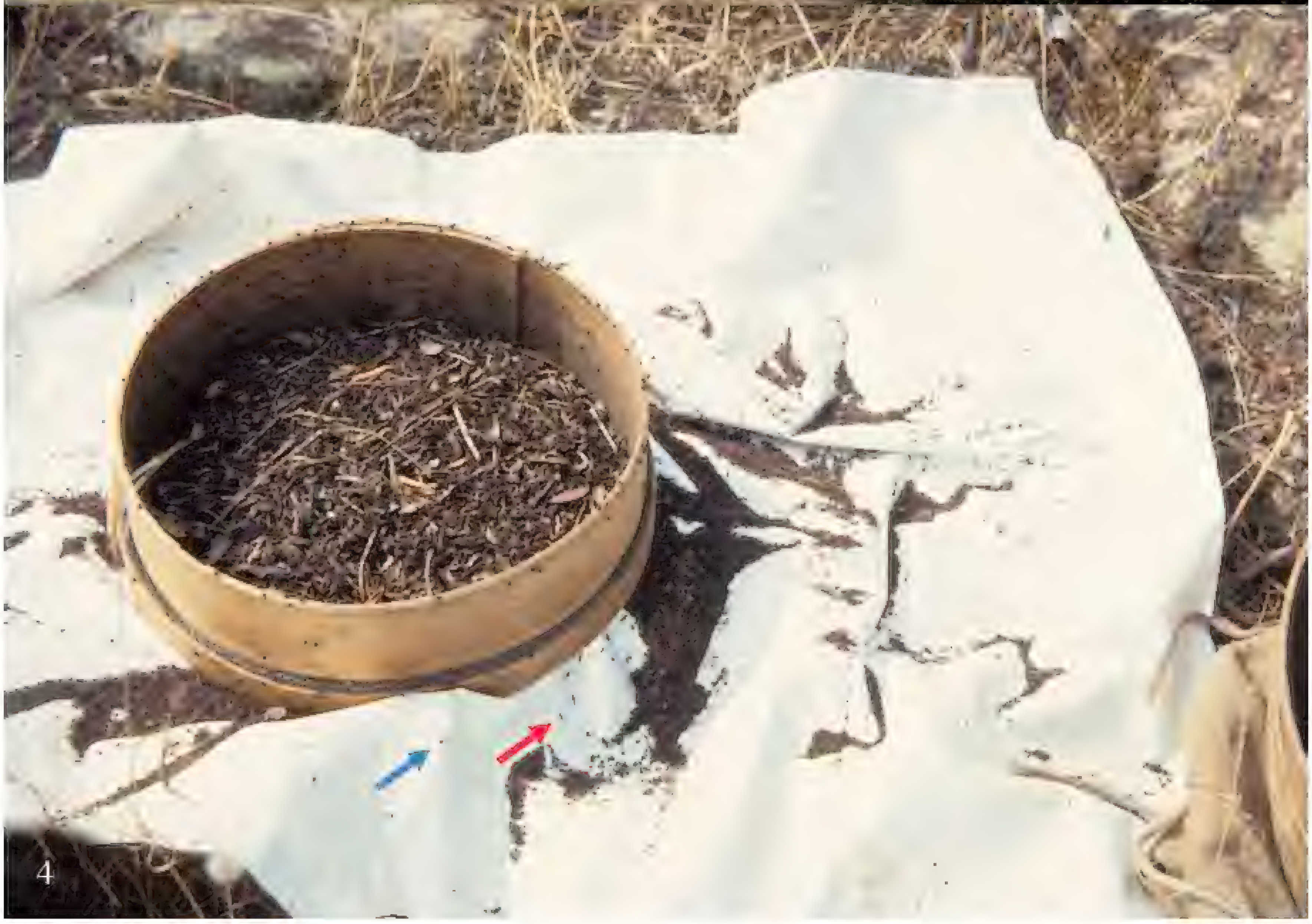
Several observations seem also to refer to individuals grouped together in a common attempt at minimizing negative abiotic factors, such as high or low temperature, or low humidity. These groups would hence be formed by individuals gathering together in most suitable microhabitats of their environment, like under stones (for humidity, and heat or cold), or in caves (for humidity and cold), with individuals remaining rather inactive, not necessarily engaged in elaborate interactions between each other, like mating. Such behaviour would be expected to occur rather on circadian and/or seasonal basis. For example all the reports pertaining to *Dianous* sp. were consistently made in subtropical climate with individuals grouped on boulders close to streams (reports 13, 14, 16–19; Figs. 7, 8); insects could seek there fresh and humid during the hottest hours of the day, but still remaining close enough to their normal habitat in order to be able to readily return there once the ambient conditions will be back to their liking. As already noted by Rougemont (1980) it is also very likely that the small group of *S. immsi* he found in January in Nepal massed together and inactive were individuals hibernating during excessive cold (report 6). Same could apply to the aggregate observed in January in Khazakstan (report 23). Similarly most observations from the Mediterranean area (reports 1, 7, 9, 10, 11, 15 and 24) and that from Uzbekistan (report 3; Figs. 20–23) might refer to populations of *Stenus* in state aestivation trying to escape excessive drought under stones, or in caves. Particularly impressing is that aggregate observed in Lebanon inside the “rove beetles cave” (report 11), where the masses of *Stenus* were “guarded” by spiders (Fig. 6).

Considering the rather individualistic normal behaviour of these insects, it seems obvious that pheromone signals drive them to form such dense masses consisting of several layer of bodies tightly piled onto each other. However the reasons which would trigger those pheromones signals remain very obscure. The most seducing hypothesis is that aggregative behaviour would facilitate reproduction, and hence those signals would be triggered on seasonal basis. This would be particularly tempting to explain when *Stenus* are surprized in compact clusters grouped above the ground on leaves of a tree (report 1), hanging on a few blades of grasses (report 4), or forming very compact masses in full view on a boulder (report 25; Figs. 24–28) or a tree (report 26; Figs. 29–33). However at least for these last two reports (25 and 26), which were those documented with the best pictures ever of the phenomenom, it seems that there were no specimens mating (see Figs. 26, 27, 32, 33). So far the only evidences of specimens *in copula* during or after an aggregation pertain to observations made in India (report 20; Fig. 14) and in Italy (report 21; Fig. 19).

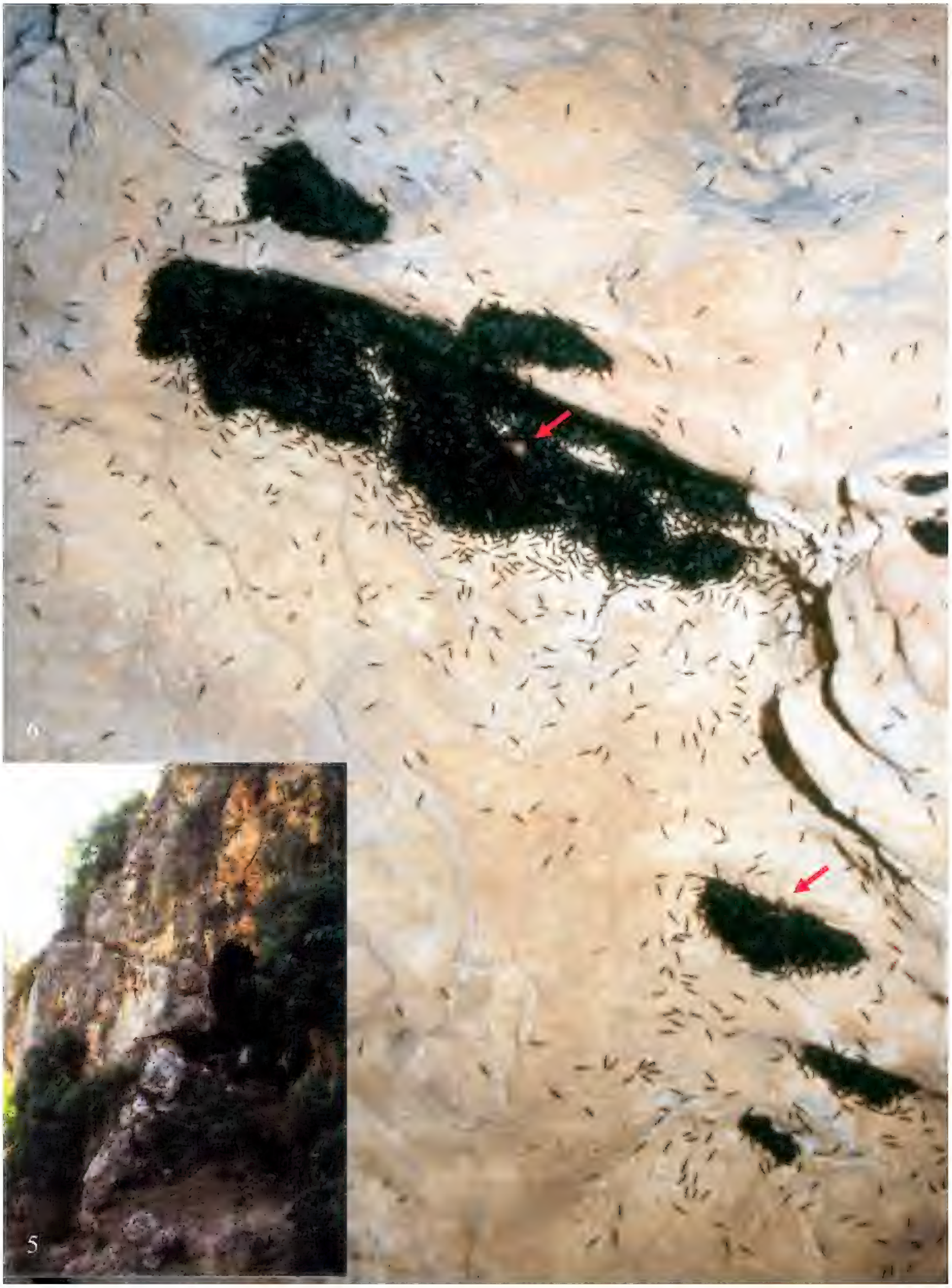
The two latter reports (20 and 21) together with report 1 are amazingly also the only three aggregates having reoccurred at least two times at the same place: on a particular tree at several days of interval for reports 1 and 20, and inside a house and its cellar over several years for report 21. Recurrence of an aggregate on a very precise location is also very hard to explain without the implication of lasting pheromone signals.



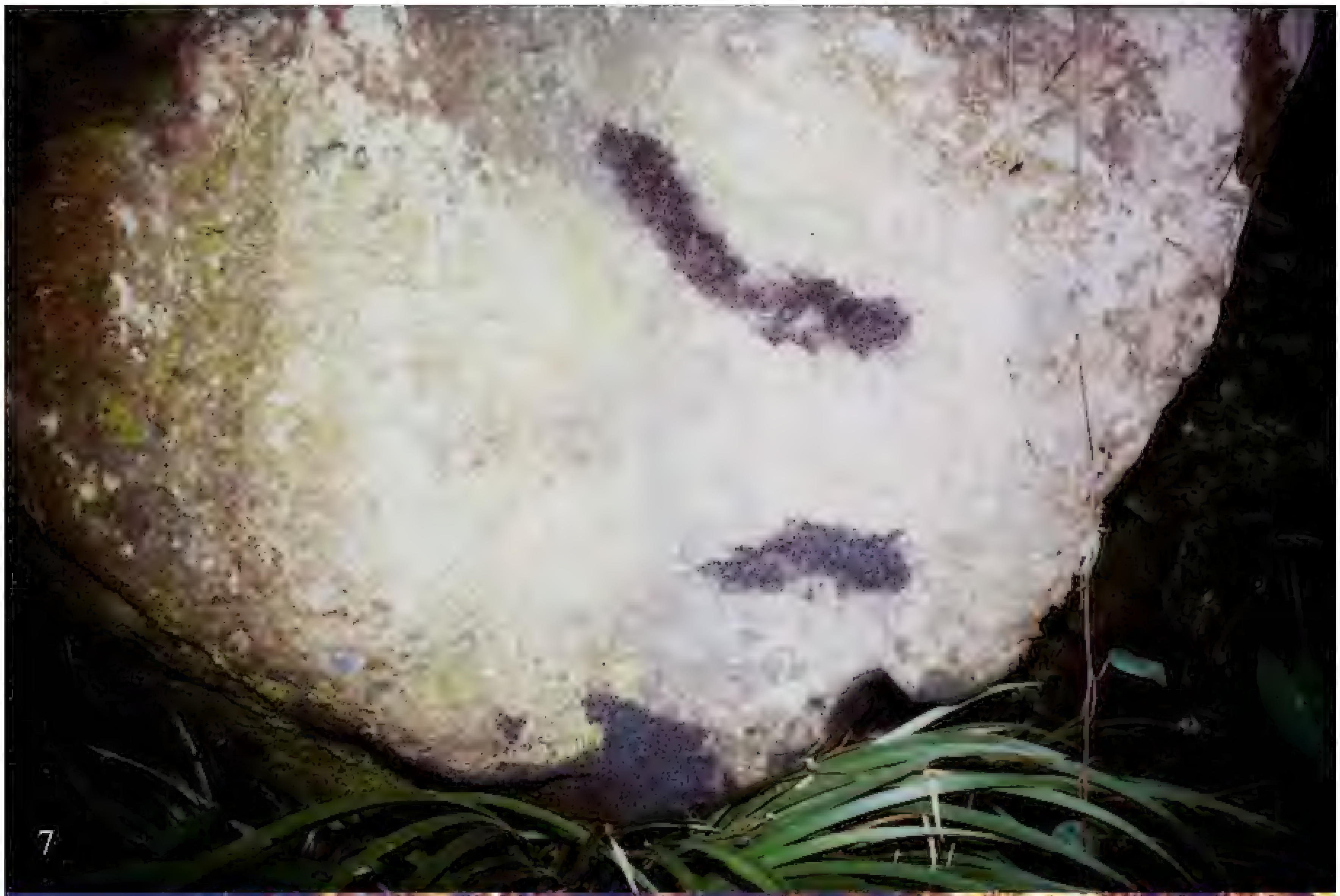
Figures 1, 2. Aggregate n° 2 (12.VI.1972: Rosas, Spain, credit A. Elbert). Views of the stone with dense multilayer masses of *Stenus* sp. (black masses), and isolated individuals walking away.



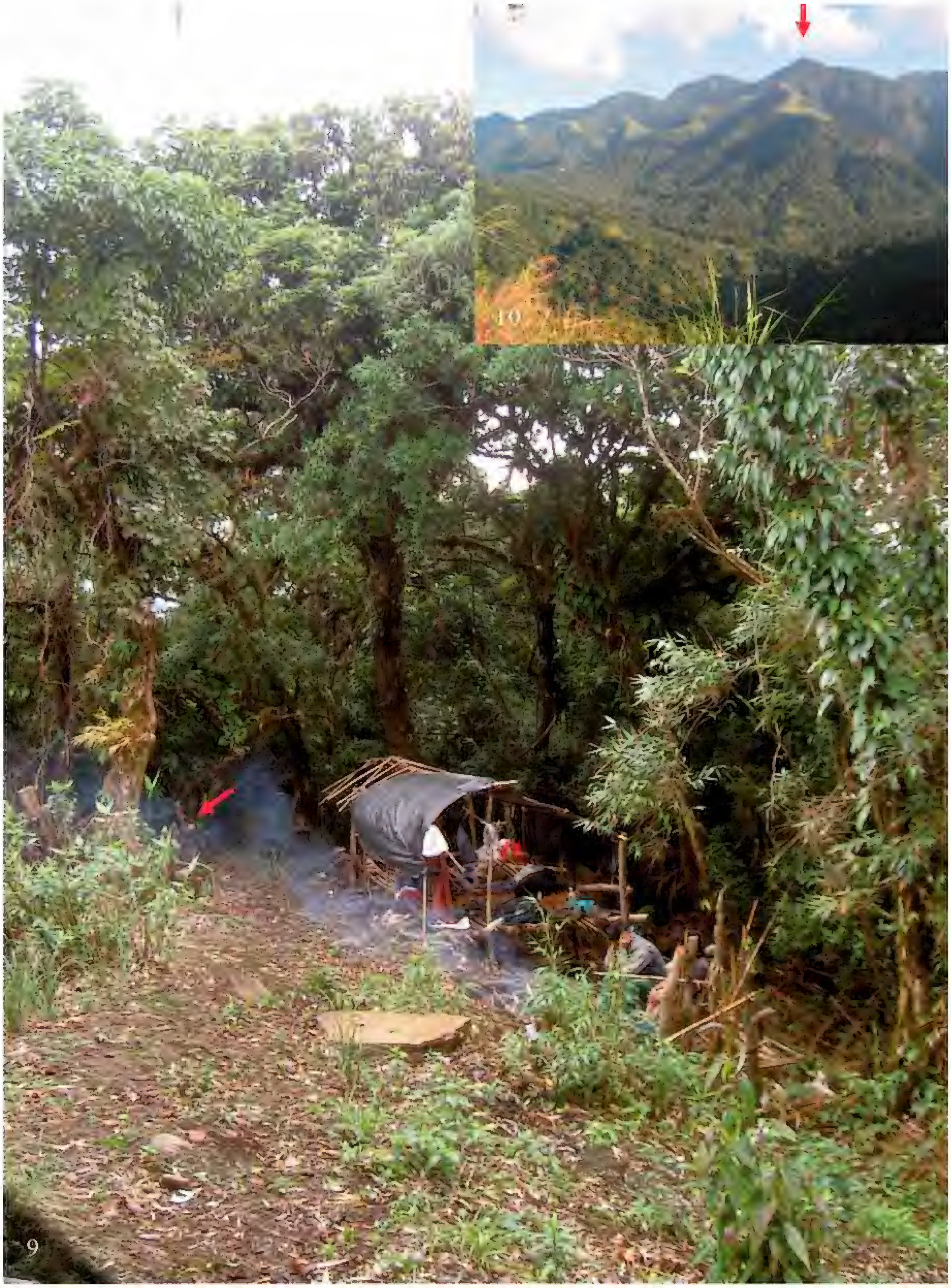
Figures 3, 4. Aggregate n° 7 (27.VI.1987: San Pietro Island, Italy, credit R. Poggi). View of the biotope and sample of the aggregate, with sifter and sheet covered with many individuals of *Stenus* (red arrow showing one) and *Apion* (blue arrow showing one) running out of the sifter and on the sheet.



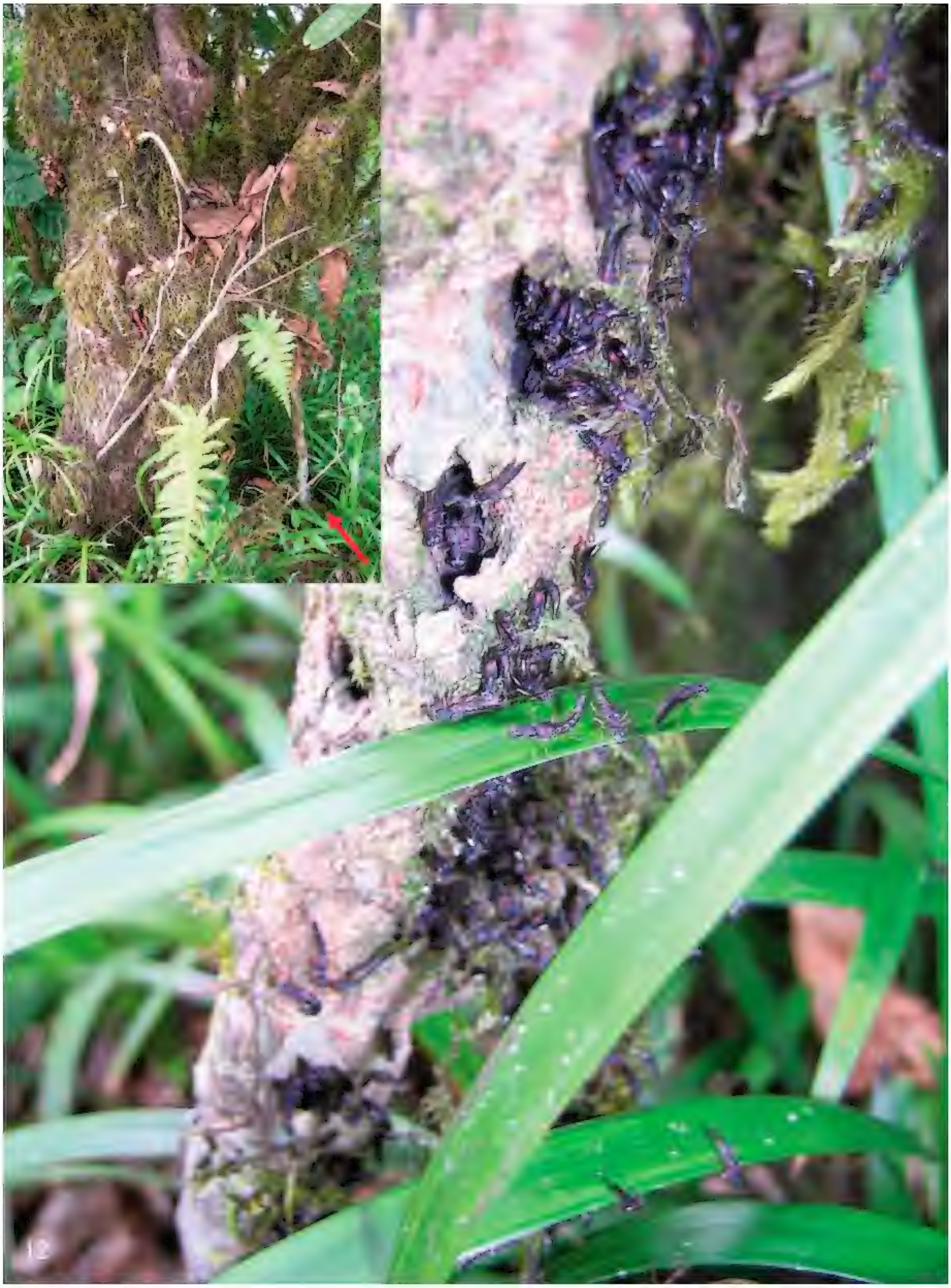
Figures 5, 6. Aggregate n°11 (June 1988: Cave Mgharet el Qlanssiyé, Lebanon, credit H. Abdul-Nour). Entrance of the cave and dense multilayer masses of *Stenus cyaneus*, the main one covering about 200 cm^2, with their « gardian spider » (red arrows).



Figures 7, 8. Aggregate n°16 (16.VIII.2000, Guangdong, China, credit G.T. Reels). Fig. 7: boulder with several thousands *Dianous banghaasi* (dark areas) densely massed in four separate groups near the base. Fig. 8: close up of upper group with individuals massed in 4 to 5 layer.



Figures 9, 10. Aggregate n° 20 (17 and 19.X.2005: Mt Barail, India, credit G. Cuccodoro). Fig. 9: view of the biotope (red arrow showing the location of the aggregate). Fig. 10: view of the western slope of Mt Barail (red arrow showing the location of the aggregate) from Haflong (North Cachar Hills, Assam).



Figures 11, 12. Aggregate n° 20 (17 and 19.X.2005: Mt Barail, India, credit G. Cuccodoro). Fig. 11: mossy stem of the tree where the aggregate was observed twice at two day of interval thousands (red arrow showing the branch photographed in figure 12). Fig. 12: densely massed *Stenus stigmatias* as if oosing out of a dead branche.

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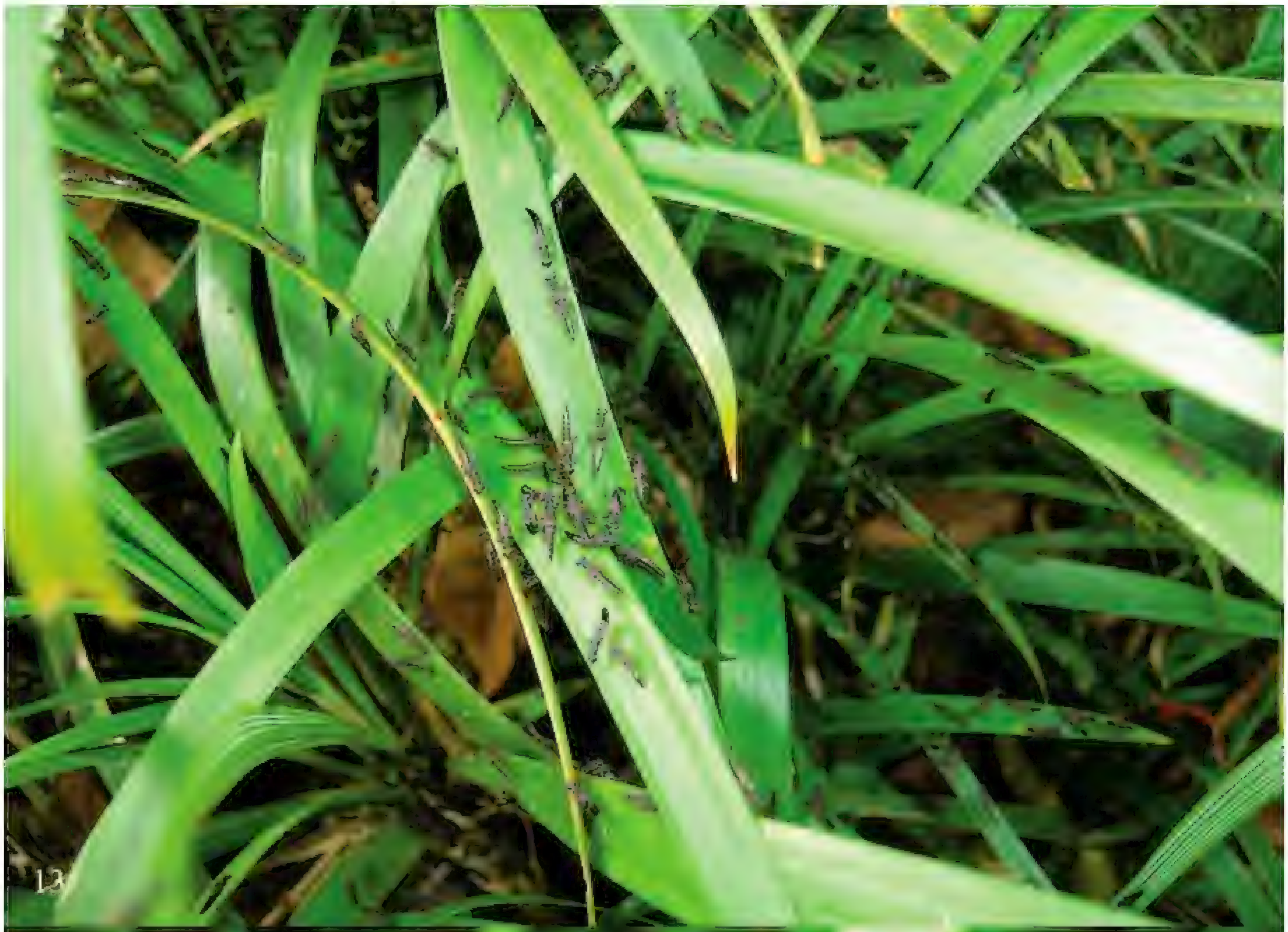

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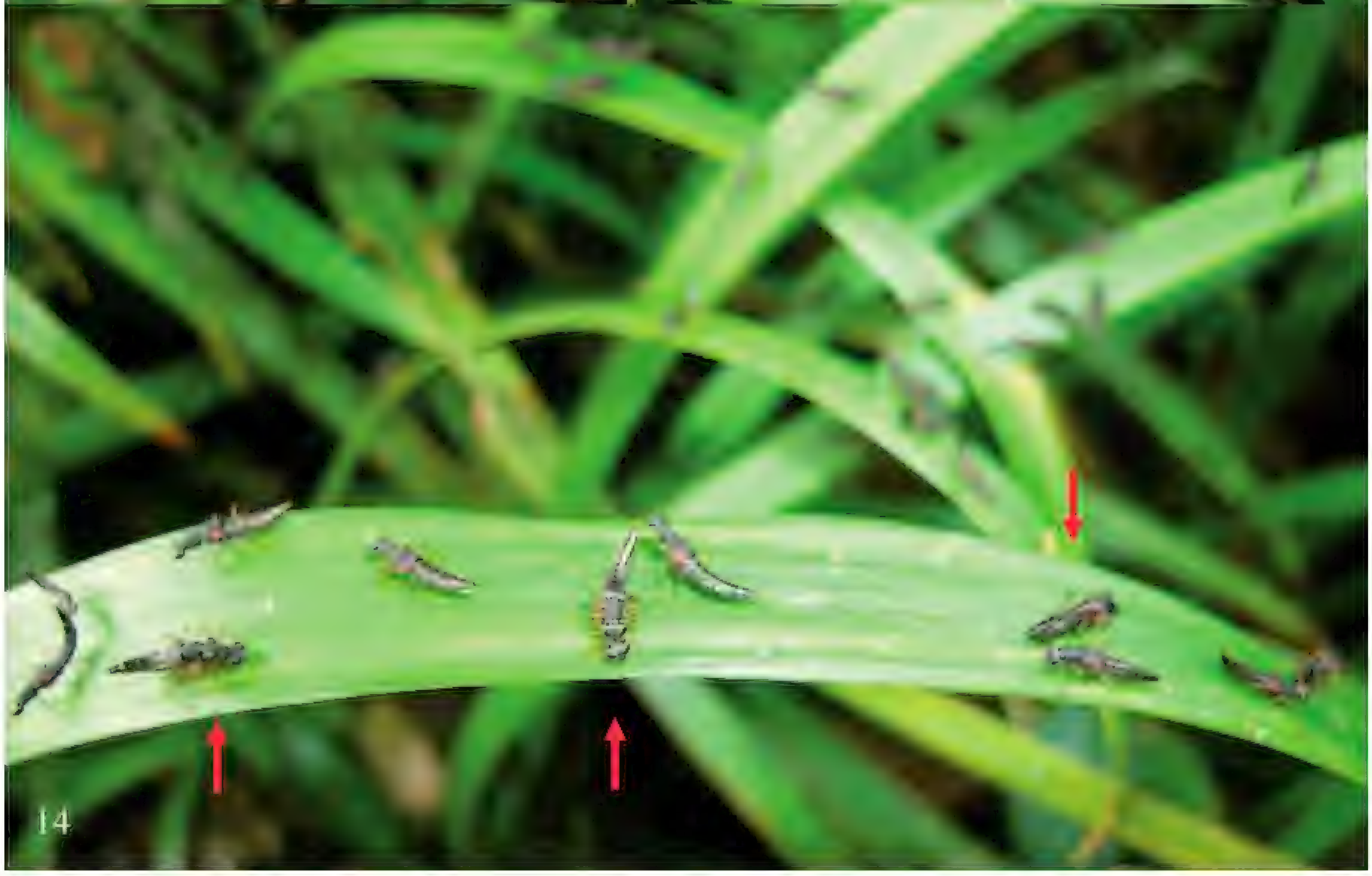
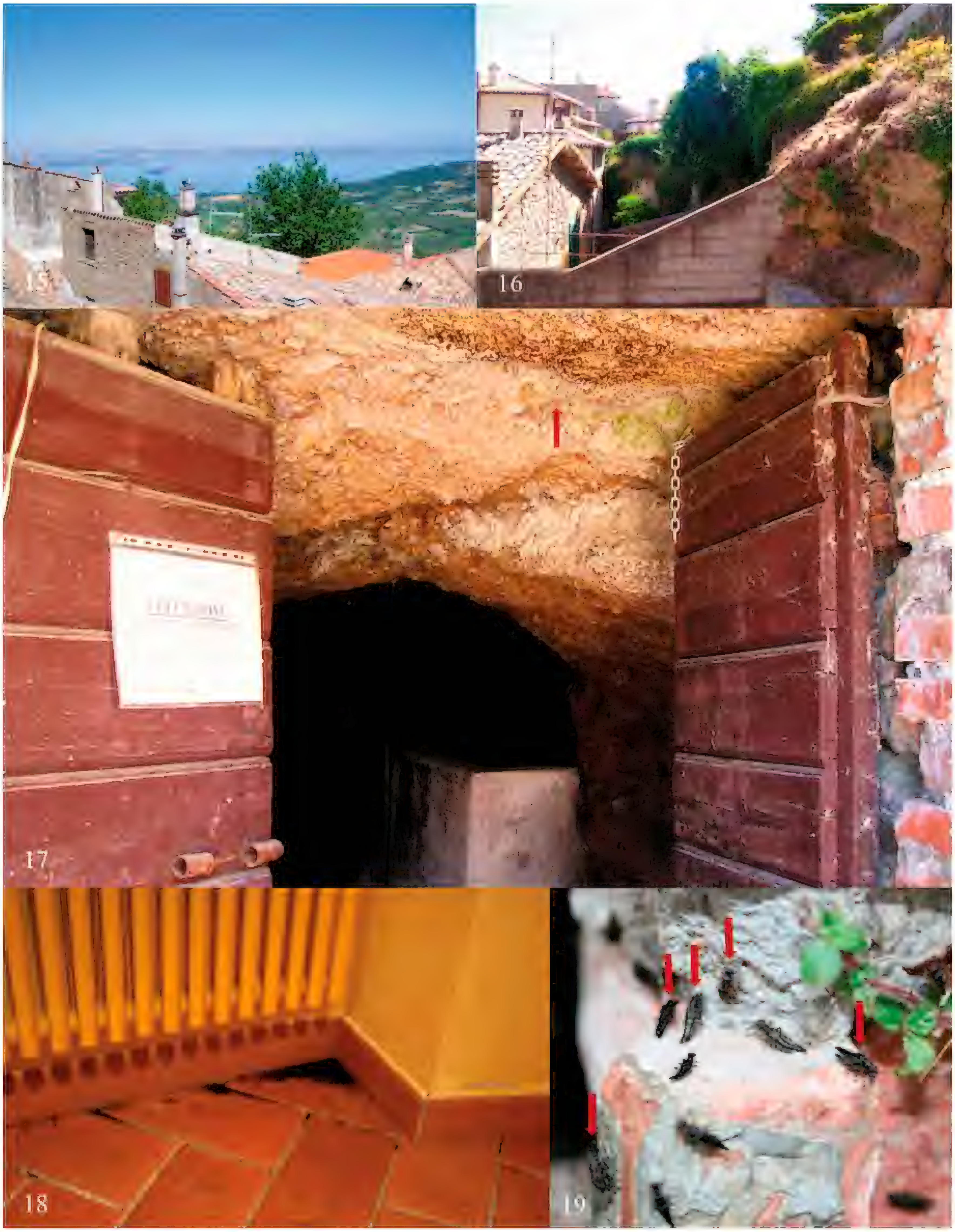
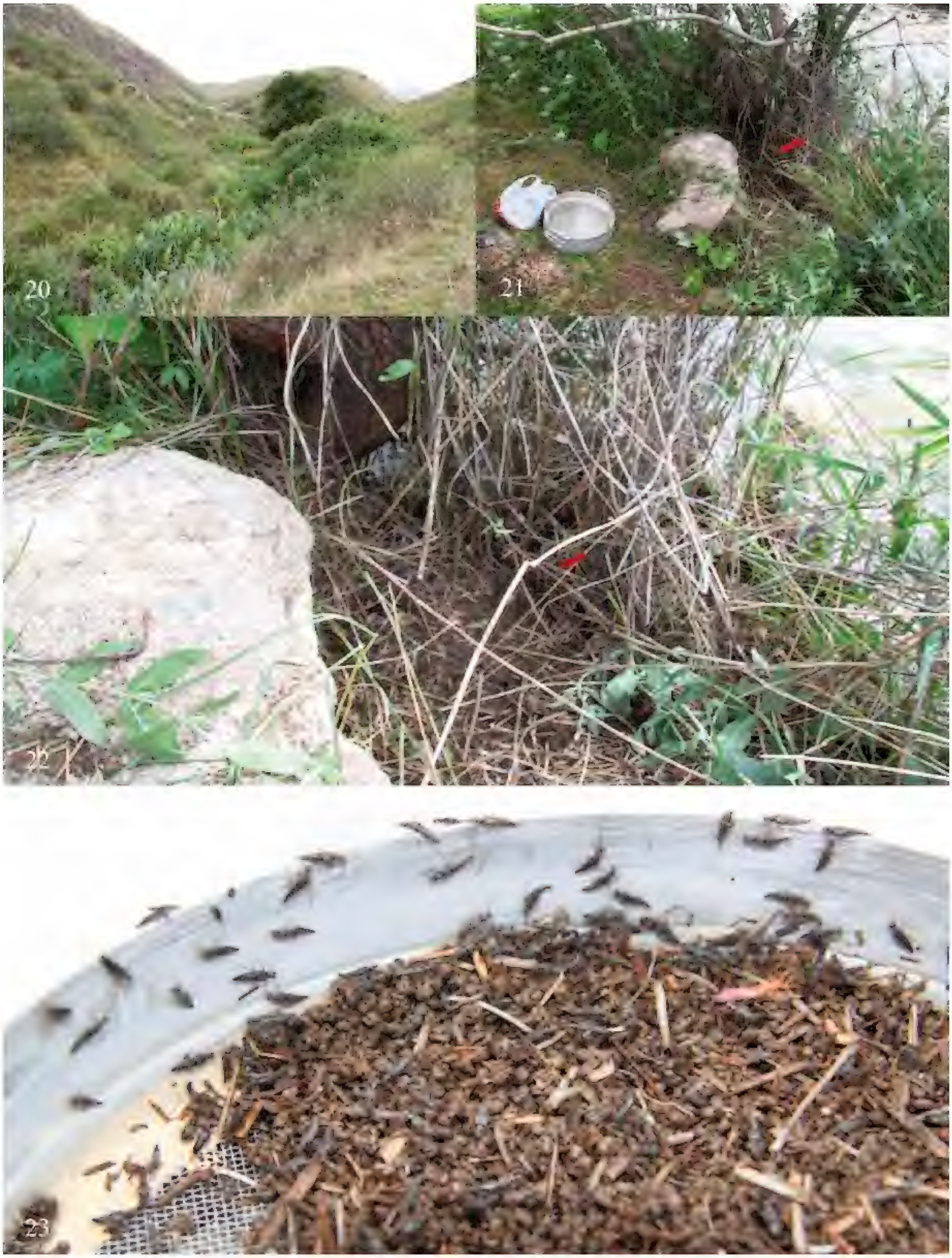


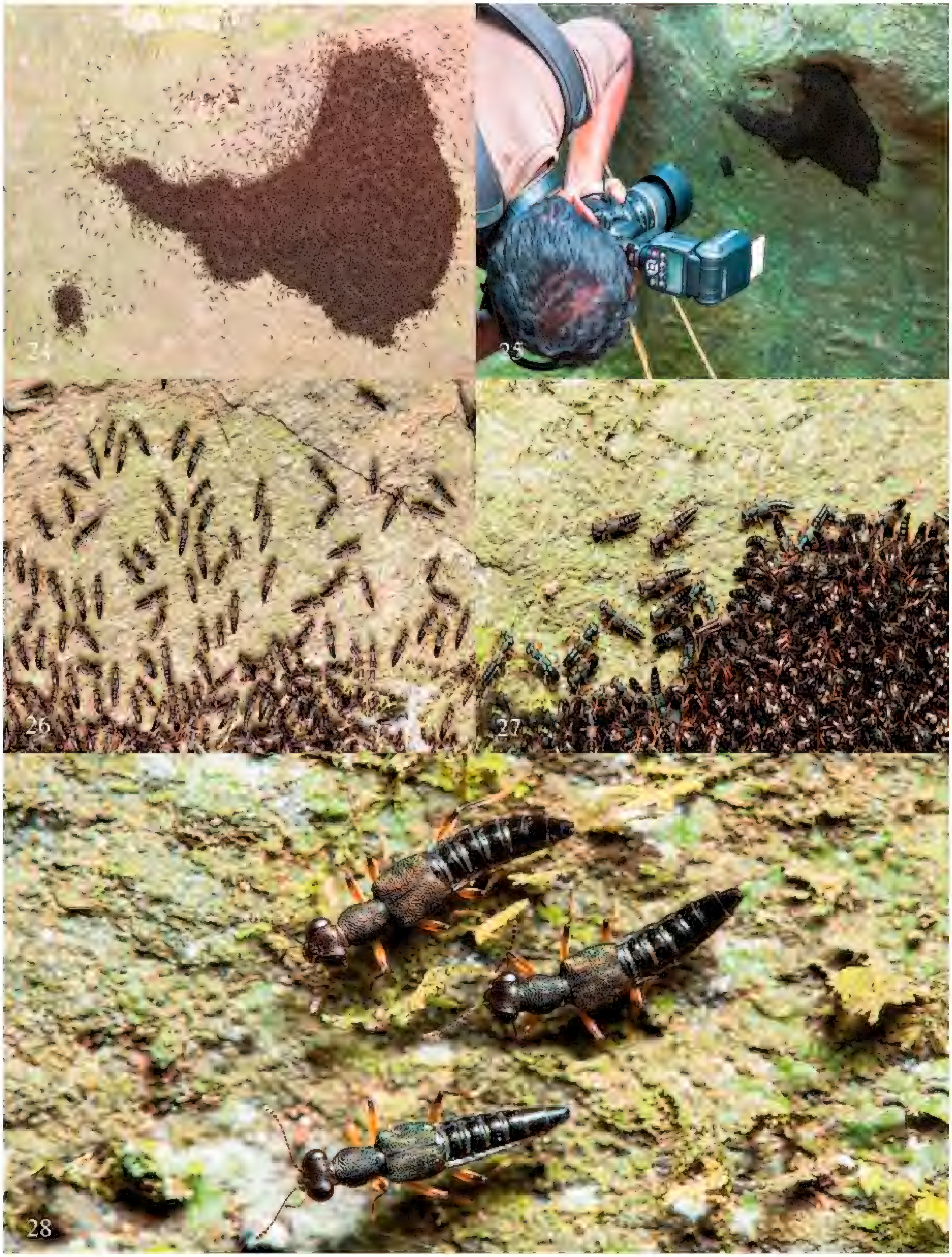
Figures 13, 14. Aggregate n° 20 (17 and 19.X.2005: Mt Barail, India, credit G. Cuccodoro). Figs. 13, 14: *Stenus stigmatias* over the vegetation near the tree of figure 11 (red arrows showing couples *in copula*).



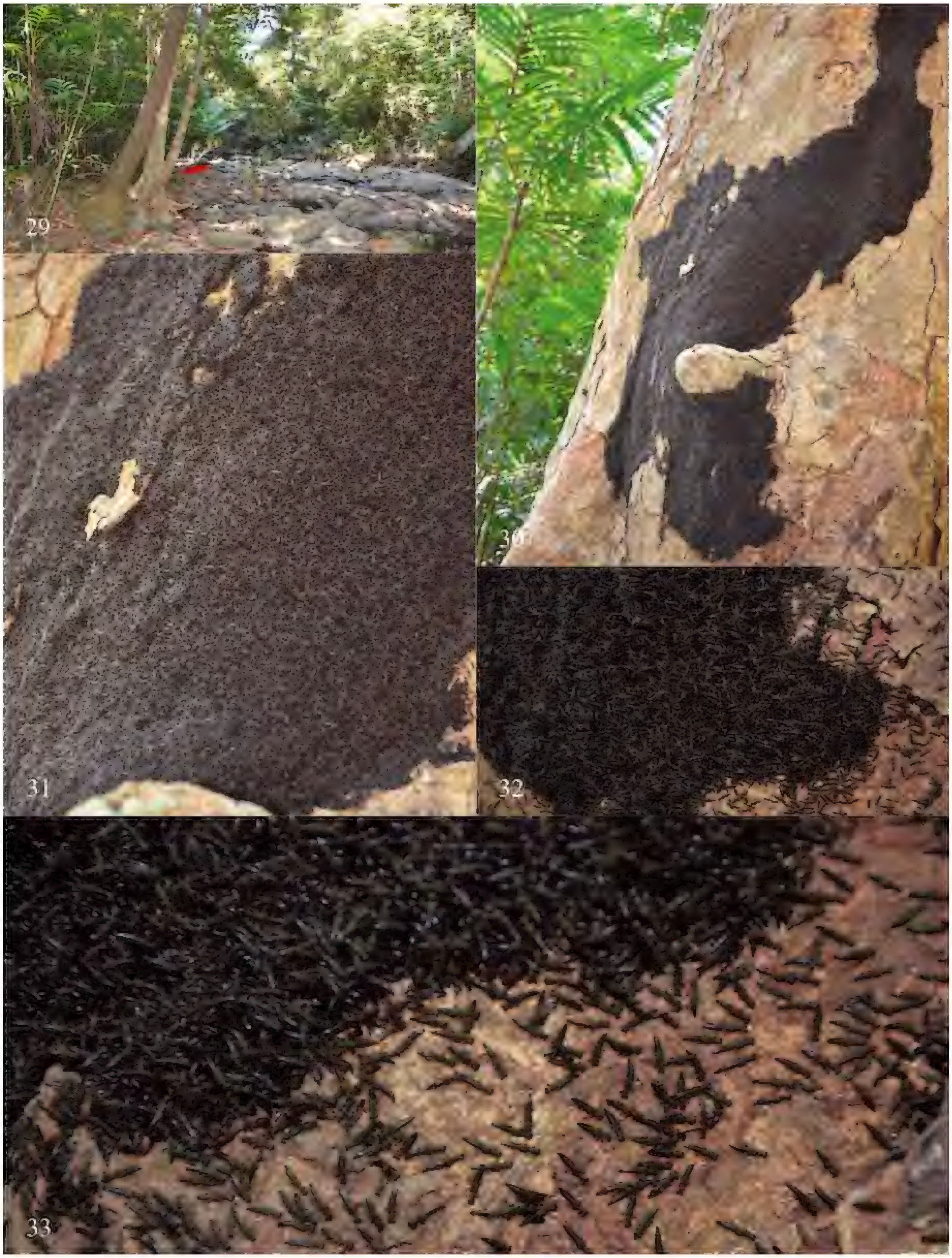
Figures 15–19. Aggregate n° 21 (September-November 2005–2008, Montefiascone, Italy, credit Anonymous, WEB (Forum Entomologi Italiani) in March 2009). Fig. 15: view of the Lake Bolsena from the site of the aggregate. Fig. 16: view of the biotope, with cellar. Fig. 17: entrance of the cellar inside which part of the aggregate occurred repeatedly in Autumn over several years17 (red arrows showing area with *Stenus*). Fig. 18: multilayer mass of *Stenus* sp. in the corner of a room inside the house. Fig. 19: *Stenus* sp. walking out of the cellar shown in figure 17 (red arrows showing couples *in copula*).



Figures 20–23. Aggregate n° 23 (15.XII.2010, Komirshi river, Kazakhstan, credit V. Katscheev). Fig. 20: view of the biotope. Figs. 21, 22: views of the microhabitat (red arrow showing the location of the aggregate). Fig. 23: sifter with hundreds *Stenus turk* running away.



Figures 24–28. Aggregate n° 25 (22.XI.2014, Virajpet, India, credit V. Baliga). Figs. 24, 25: Views of the entire *Stenus* sp. aggregate. Figs. 26, 27: details of the aggregate (note the apparent absence of couples in copula). Fig. 28: close up of three *Stenus* sp. walking away of the aggregate.



Figures 29–33. Aggregate n° 26 (5.II.2015, Agumbe, India, credit L. Podloucký). Fig. 29: view of the biotope (red arrow showing the location of the aggregate). Fig. 30: view of the main part of the aggregate. Fig. 31: close up of the central part of the aggregate. Figs. 32, 33: close ups of the lower part of the aggregate (note the apparent absence of couples in copula).

Aggregate	Year	Country	Climate	Month	Species involved	Exposure	Multilayer	Stream	Hilltop	Matings	Pictures
1	1856	France	Cool temperate	September	*Stenus cordatus*	in full view	yes	no			
2	1972	Spain	Mediterranean	January	*Stenus* sp.	hidded	yes				Figs. 1, 2
3	1972	Uzbekistan	Warm continental	July	*Stenus turk*	hidden	yes	yes			
4	1972	Greece	Mediterranean	September	*Stenus picipes*	in full view	yes	yes			
5	1977	Cyprus	Mediterranean	July	*Stenus* sp.	in full view	no	yes			
6	1979	Nepal	Subtropical	February	*Stenus immsi*	hidden	no	yes			
7	1981	Algeria	Cold semiarid		*Stenus* sp.	hidden	yes				
8	1981	Greece	Mediterranean	August	*Stenus* (6 sp.)	in full view	no	yes			
9	1983	Greece	Mediterranean	May	*Stenus* sp.	hidden	yes	yes			
10	1987	Italy	Mediterranean	June	*Stenus elegans* + *Apion* sp.	hidded	yes	yes			Figs. 3, 4
11	1988	Lebanon	Mediterranean	June	*Stenus cyaneus*	hidden	yes	yes			Figs. 5, 6
12	1988	France	Cool temperate	July	*Stenus cordatus*	hidden	yes	no	yes		
13	1994	China	Subtropical		*Dianous freyi*	in full view	yes	yes			Puthz, 2000
14	1996	China	Subtropical	May	*Dianous freyi*	hidden	yes	yes			
15	1999	Italy	Mediterranean	June	*Stenus elegans* + *Stenus cordatus*	in full view		yes			
16	2000	China	Subtropical	August	*Dianous banghaasi* + *Dianous* sp.	in full view	yes	yes			Figs. 7, 8
17	2003	China	Subtropical	May	*Dianous banghaasi* + *Dianous* freyi	in full view	yes	yes			Zhao & Li, 2004
18	2003	China	Subtropical	July	*Dianous* sp (2 sp.)	exposed	yes	yes			
19	2004	China	Subtropical		*Dianous banhaasi*	exposed	yes	yes			
20	2005	India	Subtropical	October	*Stenus stigmatias*	in full view	yes	no	yes	yes	Figs. 9-14
21	2005-2008	Italy	Mediterranean	September-November	*Stenus* sp.	hidden	yes	no	yes	yes	Figs. 15-19
22	2009	China	Subtropical	June	*Stenus* sp. (2 sp.)	in full view		no	yes		
23	2010	Kazakhstan	Warm continental	December	*Stenus turk*	hidden	yes	yes			Figs. 20-23
24	2011	Italy	Mediterranean	May	*Stenus cordatus*	in full view	no				
25	2014	India	Tropical	November	*Stenus* sp.	in full view	yes	yes		no	Figs. 24-28
26	2015	India	Tropical	February	*Stenus* sp.	in full view	yes	yes		no	Figs. 29-33

Table 1. Summary of the 26 observations of aggregates of Steninae reported since 1856 (Coleoptera Staphylinidae).

Together with the reports 12 (from France) and 22 (from China) these same two reports (20 and 21) belong even more amazingly to the four aggregates of *Stenus* found near or at the top of a local summit, with specimens over one kilometer away from their usual habitat, corroborating the suggestion by Lecoq (1991) of a possible hilltopping effect on the phenomenom. Although Steninae can fly (see report 24), they are basically very lasy flyers and prefer walking. On the top of Mt. Barail I have not seen even one specimen flying to or away of the two consecutive aggregates I watched there for over 6 cummulated hours (report 20). But the key advantage for their survival these one centimeter long rove beetles would find in walking at least half a kilometer away of their habitat up to the top of this 1800 m high summit is quite obscure to me.

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My colleagues and friends V. Puthz (Schlitz, Germany), G. de Rougemont (London, United Kingdom) A. Ryvkin (Moscow, Russia) and L. Tang (Shanghai, China) helped me in various ways, notably by forwarding me all the published and unpublished informations they had gathered on the topic over decades dedicated to the study of Steninae, and I warmly thank them again here. For providing precious informations and/or pictures used in this paper my thanks are also extended to H. Abdul-Nour (Jdeit-el-Matn, Lebanon),V. Baliga (Bangalore, India), A. Elbert (Monheim, Germany), G. Gridelli (Italy), J. Kadlec (Strakonice, Czech Republic), S. Karimbumkara (Bangalore, India), G. Katschak (Kleve, Germany), V. Katscheev (Russia), J. Král (Prague, Czech Republic), P. Krásenský (Chomutov, Czech Republic), D. Liebegott (Frankfurt, Germany), H. Malicky (Lunz, Germany), A. Marletta (Catania, Italy), L. Podloucký (České Budějovice, Czech Republic), R. Poggi (Genoa, Italy), G.T. Reels (Yuen Long, Hong Kong), and S. Vit (Geneva, Switzerland).

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Biodiversity Journal, 2017, 8 (1): 145–150 **MONOGRAPH**

The alien leafhopper *Balclutha brevis* Lindberg, 1954 (Hemiptera Cicadellidae) and its hostplant, the invasive Poaceae *Pennisetum setaceum* (Försskal) Chiov.: a real risk in the scenario of Mediterranean land biodiversity?

Vera D'Urso*, Oscar Lisi & Giorgio Sabella

Department of Biological, Geological and Environmental Sciences - Section of Animal Biology, University of Catania, via Androne 81 - 95124 Catania, Italy
*Corresponding author: dursove@unict.it

ABSTRACT The possible effects on Mediterranean biodiversity of the alien leafhopper *Balclutha brevis* Lindberg, 1954 (Hemiptera Cicadellidae) and its alien hostplant, *Pennisetum setaceum* (Försskal) Chiov., are discussed; *Pennisetum setaceum* is a perennial grass of Poaceae spread worldwide and recently colonizing very quickly also Mediterranean countries, it being an invasive species that colonises several environments and is able to modify ecosystems replacing the herbaceous indigenous vegetation. *Balclutha brevis*, described from the Canary Islands, has been reported in Sicily and Malta Islands. In Sicily, conspicuous populations of this species, with specimens of different generations living together during the whole year, are present. A *Wolbachia* Hertig, 1936 strain and the Trichogrammatidae *Oligosita balcluthae* Viggiani et Laudonia, 2015, parasitoid of eggs, affect *B. brevis*. The aggressiveness of *P. setaceum* and the speed of colonization of *B. brevis* could cause a banalization of the flora and also the fauna with modification of the entomocoenosis and possible transmission of disease to wild and cultivated plants.

KEY WORDS Alien species; *Balclutha brevis*; *Oligosita balcluthae*; *Pennisetum setaceum*; Sicily; *Wolbachia*.

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INTRODUCTION

The alien species of leafhopper *Balclutha brevis* Lindberg, 1954 (Hemiptera Cicadellidae), living on the alien Crimson Fountain Grass *Pennisetum setaceum* (Försskal) Chiov., has been recently reported in Sicily (Bella & D'Urso, 2012).

The Crimson Fountain Grass is a perennial Poaceae with a thermo-cosmopolitan distribution. The areas of origin of this species are North and East Africa, the Near East and the Arabian Peninsula; from these areas the species has spread worldwide, recently also to Mediterranean countries: the Canary Islands, Southern France, Southern Spain, Balearic Islands, Southern Italy, Sicily and Sardinia. Recently reported also from Malta Island (D'Urso & Mifsud, 2012). Its spread is linked especially to its use as an ornamental, it having an attractive appearance, low nutritional requirements and resistance to soil aridity, also in its cultivar "*rubrum*" (Figs. 1, 2).

According to Pasta et al. (2010), *P. setaceum* was reported for the first time in Sicily by Bruno (1939) (sub *P. ruppelii*) in the Botanical garden of

Palermo, where seeds imported from Abyssinia were planted in 1938.

Pennisetum setaceum was found in natural environment in about 1959 on the slopes of Mount Pellegrino (Pignatti & Wikus, 1963) and Catania (Borruso & Furnari, 1960) (sub *P. villosum* R. Brown). Currently, this species is in rapid expansion along the coastal areas and the main roads of Sicily (D'Amico & Gianguzzi, 2006; Giardina et al., 2007; Pasta et al., 2010) where there are suitable environmental conditions.

Outside of its native areas, *P. setaceum* is an invasive species that colonises several environments and is able to modify and to alter ecosystems replacing the herbaceous indigenous vegetation (Pasta et al., 2010). It also increases the risk of fire since it is highly flammable (Rahlao et al., 2009), resists after fire and indeed its vegetation is stimulated by fire (Smith & Tunison, 1992; Brooks & Pyke, 2001). As widely documented, it has escaped from cultivation as ornamental many times (e.g. in the USA) (Poulin et al., 2005) and it is a major threat to native vegetation in many areas (also natural reserves) such as in the Hawaii, where it is subjected to control and eradication methods (Castillo et al., 2007).

Balclutha brevis is a leafhopper 3.20–3.80 mm long, yellowish-green (Fig. 3). The species of the genus *Balclutha* Kirkaldy, 1900 live on various grass species by feeding sap; the genus has a cosmopolitan diffusion with about seventy described species (McKamey, 2010); in the Mediterranean area 1/3 of those species are present with at least 6 species reported also in Italy. *Balclutha brevis*, described from the Canary Islands by Lindberg (1954), was subsequently reported from Cape Verde Islands. Recently, the species has been reported from Sicily (Bella & D'Urso, 2012) and Malta Islands (D'Urso & Mifsud, 2012).

The presence in Sicily of this alien species could be due to introduction via North Africa, where it is supposed to be present though not yet reported due to the lack of fieldwork. In Malta, the species was probably introduced together with *P. setaceum*, used as ornamental plant and now spreading rapidly (Mifsud, personal communication). According to Aguin Pombo et al. (2005), *B. brevis* is probably a native species from the Cape Verde Islands. In our opinion, this species is likely native from the same native range of *P. setaceum* (the wide area comprising North and East Africa, the Near East and the Arabian Peninsula) and the leafhopper should be considered as an established alien outside that area.

MATERIAL AND METHODS

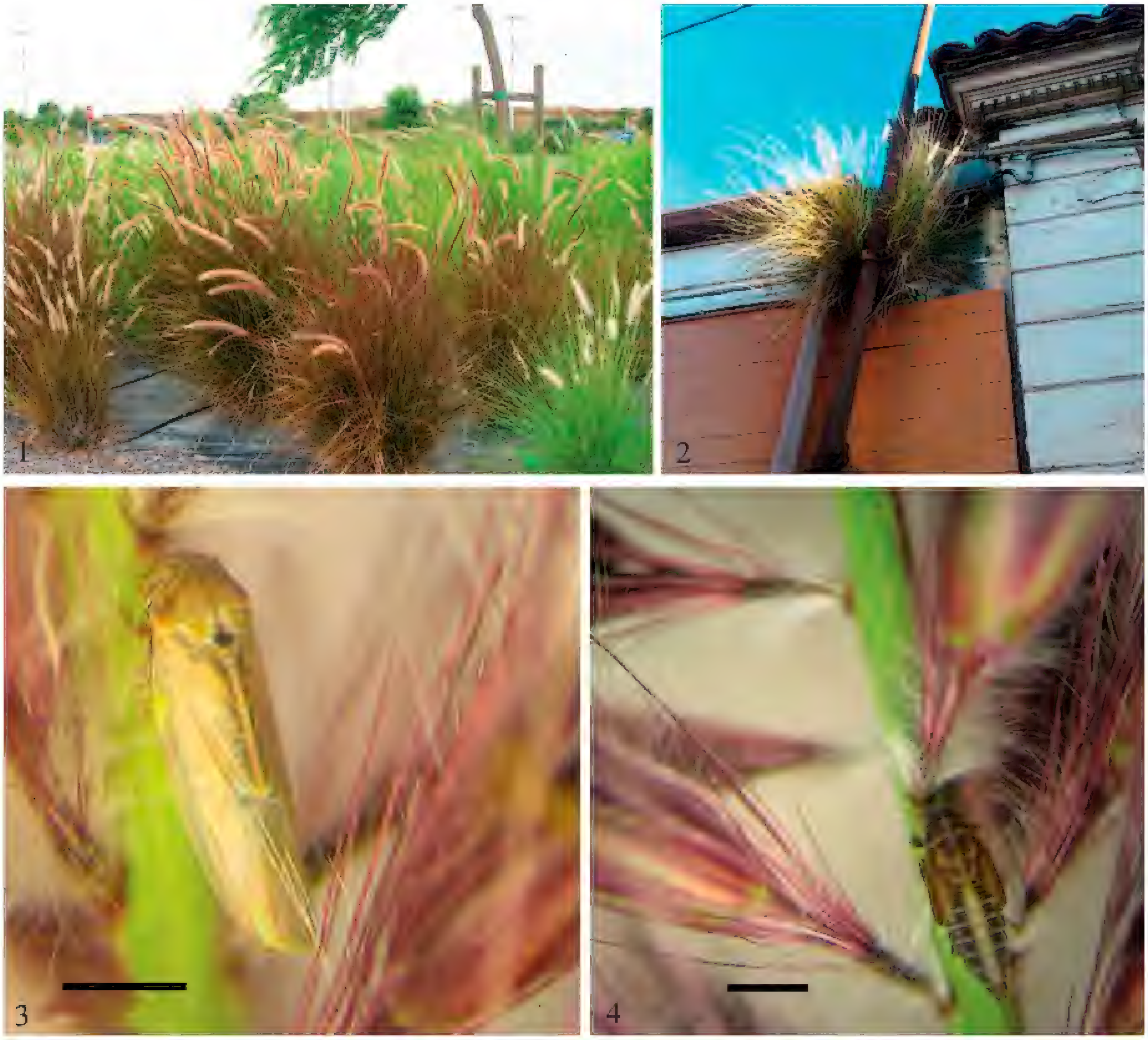
The present paper takes into consideration part of the results of an investigation conducted in the territory of the town of Catania (on which a specific, detailed paper on the life cycle of *B. brevis* is in preparation): during the years 2012–13 two sites, one in the town and one in a suburban area, were monitored about every twenty days. Ten ears of *P. setaceum* were collected every time and all arthropods found on them were identified and counted.

RESULTS AND DISCUSSION

In Sicily, conspicuous populations of adults and immature stages (Fig. 4) of *B. brevis* develop exclusively on *P. setaceum* ears (also on the cultivar "*rubrum*"), both on spontaneous and ornamental plants. The eggs are laid in groups inside the glumes. The observed life cycle of *B. brevis* lasted about 17 days and several generations follow one another throughout the year, with specimens of different generations living together; actually, all stages (immature stages, adults and eggs) can be found together in every period of the year.

When these insects are very numerous, the ears contain many microdrops of honeydew that blur the plants heavily (Fig. 5). In addition, the honeydew can attract other feeders especially Formicidae; as a matter of facts, the highest number of ants found corresponded well to the peaks of *B. brevis* population. The honeydew could attract also several species of Apoidea, especially *Apis mellifera* Linnaeus, 1758. In our land, honeydew honey is produced when there are large populations of aphids or whiteflies.

Up to now, little is known about the fauna associated to *P. setaceum*; a report concerns a new aphid (Homoptera Aphididae) from Saudi Arabia and Eritrea (Aldryhim & Ilharco, 1997). In Sicily, the arthropod fauna associated to the Crimson Fountain Grass is not very rich. Ants are the most numerous in specimens (represented by 6 species) followed by the Trichogrammatidae (although present with a



Figures 1, 2. *Pennisetum setaceum* as ornamental green near Catania (Fig. 1) and a clump living on an house wall in the city (Fig. 2). Figures 3, 4. *Balclutha brevis* adult (3) and fifth stage (4). Scale bar = 1 mm

single species); rare araneids, beetles and bugs but with more species (Table 1).

The Trichogrammatidae (Hymenoptera Chalcidoidea) include parasitoid of insect eggs; the species found, *Oligosita balcluthae* Viggiani et Laudonia, 2015 was identified into the eggs of *B. brevis*. *Oligosita balcluthae* belongs to the *collina*-group and is very similar to *O. biscrensis* Nowicki, 1935 known only for a female collected on palm orchad in Biskra (Northern Sahara, Algeria) (Bella et al., 2015). The above mentioned similarity could confirm our hypothesis of the provenience in our land of *B. brevis* from North Africa. The presence of the parasitoid indicates that there is a natural population control of the leafhopper; besides, from this it can be inferred that *B. brevis* is well established in Sicily for a time long enough to allow the consolidation of the relationship between parasitoid and host.

In addition, recently a *Wolbachia* Hertig, 1936 strain, belonging to the taxonomic supergroup B, in males and females specimens of *B. brevis* from Sicily, has been detected by molecular screening study (PCR) with three *Wolbachia* specific genes (16S rRNA, ftsZ, wsp) (Pappalardo et al., 2016).

Wolbachia is the most widespread intracellular α-proteobacteria maternally inherited endosymbiont of insects and nematodes. The well known ef-

FORMICIDAE	6 species
TRICHOGRAMMATIDAE	*Oligosita balcluthae*
APHIDOIDEA	at least 1 species
THYSANOPTERA	at least 1 species
ACARINA	at least 1 species
ARANEIDA	at least 3 species
COLEOPTERA	at least 3 species
HETEROPTERA	at least 2 species

Table 1. Taxa of arthropods collected on *P. setaceum*.

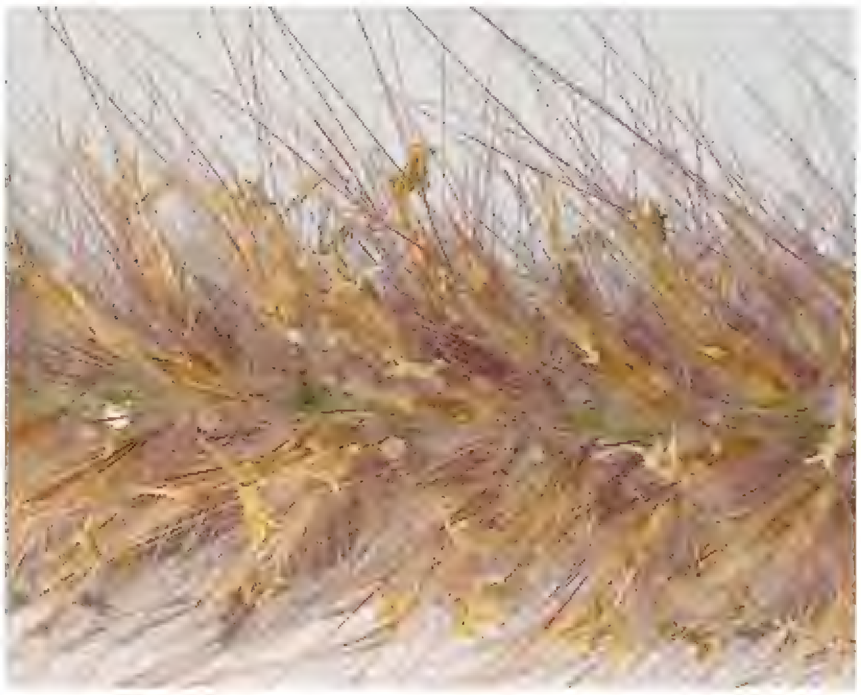


Figure 5. Ear of *Pennisetum setaceum* with drops of honeydew.

fects of *Wolbachia* on reproduction of its hosts (e.g., cytoplasmic incompatibility, parthenogenesis, male killing, feminizing of genetic males and modifying fecundity) considered, it can be hypothesized that these bacteria have influenced biology, ecology, diversification and speciation of their hosts (Lis et al., 2015). In spite of *Wolbachia* infections in both males and females of *B. brevis*, no morphostructural alteration commonly related to the presence of the bacterium, has been noticed in all the examined specimens (Pappalardo et al., 2016).

It is known that host plants can mediate *Wolbachia* infection in phytophagous insect populations. The natural horizontal transmission of *Wolbachia* can take place by consumption of infected or contaminated food, e.g. plant sap and/or from parasitoids, e.g. parasitoidal wasps.

The Crimson Fountain Grass could have mediated *Wolbachia* transmission from infected *Balclutha* to other insects and vice versa. Moreover, it is not inconceivable that the infection could be transmitted either by predation (some injury, e.g. by wasp) or more probably by parasitoids, which may function as a vector for *Wolbachia* bacteria and transfer it to other arthropods (Lis et al., 2015).

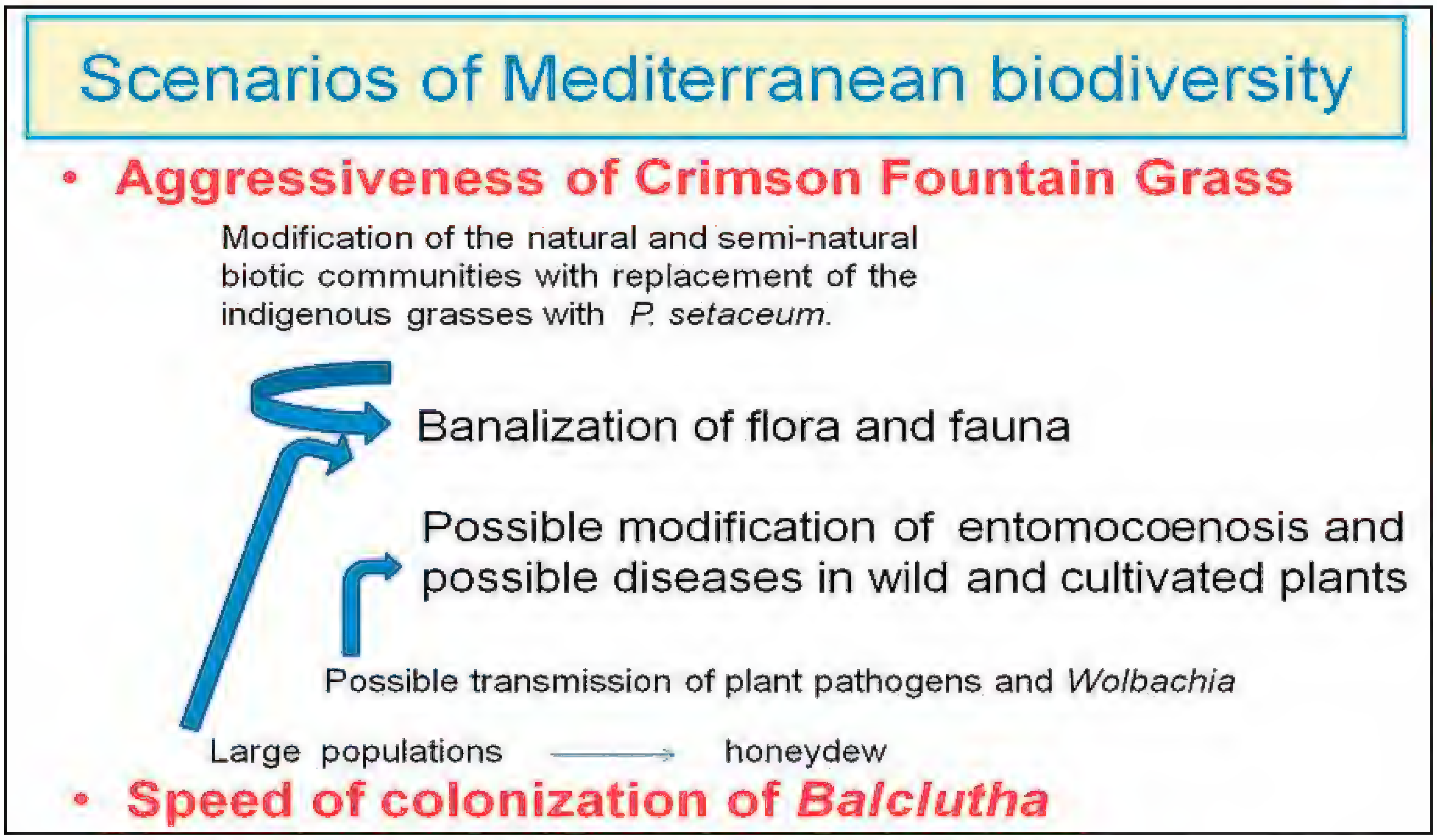
To date, there is no evidence for a vector role of *B. brevis* and, moreover, the species has not been found jet by us on any other grass species except for *P. setaceum*. However, some species belonging to the genus *Balclutha* are vectors of plant diseases. According to Han (2012), *B. punctata* (Fabricius, 1775) is able to transmit mulberry dwarf phytoplasma to mulberry; according to Morgan et al. (2013), *B. rubrostriata* (Melichar, 1903) is known to be a vector of the phytoplasma that causes sugarcane white leaf disease to sugarcane and according to Dakhil et al. (2011), almond witches'- broom phytoplasma in Lebanon was also detected in *Balclutha* sp., therefore considered potential phytoplasma carrier.

In addition, in Mississippi, *P. setaceum* resulted positive to Maize Dwarf Mosaic Virus and Sugarcane Mosaic Virus. These viruses are transmitted by sap and by several species of aphids (Rosenkranz, 1980). In conclusion, it cannot be excluded *a priori* a possible extension of the diet for *B. brevis* in new habitats colonized, or its possible role in the transmission of plant pathogens.

IMPACT ON MEDITERRANEAN BIODIVERSITY

As already emphasised by Pasta et al. (2010), *P. setaceum* is a strongly invasive species in rapid expansion which threatens to supplant the natural and ruderal vegetation of many Sicilian environments; this can happen even in the southern European countries where it is an alien species (as it happened for example in parts of Hawaii). The result will be a banalization of the flora and also of the fauna. According to Litt & Steidl (2010) while invasions by nonnative plants alter the structure and composition of native plant communities, those invasions can also alter the function of ecosystems for animals that depend on plants for food and habitat. Consequently to the spread of *P. setaceum*, the presence of *B. brevis* will rapidly increase as well.

As already stated, though there is no evidence for a role of vector of *B. brevis* in the transmission



Scenarios of Mediterranean biodiversity

- **Aggressiveness of Crimson Fountain Grass**

Modification of the natural and semi-natural biotic communities with replacement of the indigenous grasses with *P. setaceum*.

Banalization of flora and fauna

Possible modification of entomocoenosis and possible diseases in wild and cultivated plants

Possible transmission of plant pathogens and *Wolbachia*

Large populations → honeydew

- **Speed of colonization of *Balclutha***

Figure 6. Actions of *Pennisetum setaceum* and *Balclutha brevis* on the Mediterranean biodiversity.

of plant pathogens, it cannot be excluded a potential transmission of phytoplasmas and viruses if *B. brevis* moves to other host plants (to be monitored) and/or if other insects feed on the sap of *P. setaceum.*

One has to consider also the effect of *Wolbachia* and its possible transmission, vertical and horizontal, to other taxa, (e.g. the sap feeders Homoptera and Heteroptera) and to parasitoid wasps.

The result could be a modification of entomocoenosis and the possibility of diseases on wild and cultivated plants: the latter hypothesis appears at the moment quite unrealistic.

In addition, a positive action of the massive presence of *B. brevis* could be the possible production of honeydew honey (Fig. 6).

CONCLUSIONS

In the light of the discussed framework, with the linked risks, some recommendations are necessary:

- *B. brevis* is probably more widespread than it appears; it is necessary to check in other Mediterranean areas with Crimson Fountain Grass and, in addition, to check if the leafhopper can live on other herbaceous plants, especially Graminaceae.

- The knowledge about the biology of the parasitoid *O. balcluthae* should be improved.

- According to Pasta et al. (2010) the spread of Crimson Fountain Grass should be monitored and the plant should be kept under control by means of eradicating new populations to avoid an eco-catastrophe in Sicilian coasts. In Hawaii, containment and eradication programs of this alien plant have been implemented; the same protocols should be followed also in the European countries.

-The use and sale of *Pennisetum* as ornamental plant should be strongly discouraged, if not forbidden.

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Biodiversity Journal, 2017, 8 (1): 151–184 **MONOGRAPH**

Study on flora and Auchenorrhyncha biocenoses (Insecta Hemiptera) in moist areas considered restricted relics of the ancient Lacus Velinus in the provinces of Terni and Rieti (Umbria and Latium, Italy)

Adalgisa Guglielmino[1*], Enrico Scarici[1], Alessandro De Santis[2] & Christoph Bückle[3]

[1]Department of Agriculture and Forestry Science, University of Tuscia, Viterbo, Italy
[2]Via Colli San Silvestro 5, I-02010 Santa Rufina, Cittaducale (Rieti), Italy
[3]Neckarhalde 48, D-72070 Tübingen, Germany
[*]Corresponding author, e-mail: guglielm@unitus.it

ABSTRACT A research on vascular plants and Auchenorrhyncha biocenoses in moist areas of the provinces of Terni (Umbria) and Rieti (Latium) was conducted from 1999 to 2015. Prevalently four areas were studied: Lago di Piediluco, Lago di Ventina, Lago Lungo and Lago Ripasottile. 267 taxa of vascular plants are recorded on the whole. Species of particular interest are *Butomus umbellatus*, *Carex acutiformis*, *C. elata*, *C. pseudocyperus*, *C. paniculata*, *Cladium mariscus*, *Epipactis palustris*, *Frangula alnus*, *Glyceria maxima*, *Hydrocharis morsus-ranae*, *Nuphar lutea*, *Oenanthe aquatica*, *Orchis incarnata*, *Ranunculus lingua*, *Rorippa amphibia*, *Rumex hydrolapathum*, *Scutellaria galericulata* and *Viburnum opulus*, all included in the Regional Red Lists of Italian Plants of Umbria and Latium. 162 Auchenorrhyncha species were collected. Four species (*Cixius remotus*, *Kelisia punctulum*, *Anakelisia fasciata* and *Megamelodes lequesnei*) are recorded for the first time for Italy, five (*Kelisia praecox*, *Struebingianella lugubrina*, *Chloriona smaragdula*, *Hishimonus* cf. *hamatus* and *Metalimnus formosus*) are new records for the Apennine Peninsula ("S" in the checklist of the Italian fauna). For some species of special interest, their ecology, life cycle and distribution are discussed. 60 taxa are strictly correlated with moist habitats. The investigated areas are of high relevance for nature conservation as they constitute small relics of the ancient Lacus Velinus, where several stenotopic Auchenorrhyncha species occur, associated particularly with moist vegetation.

KEY WORDS flora; faunistics; ecology; phenology; biogeography; environmental conservation.

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INTRODUCTION

The Lacus Velinus originated in the Pleistocene and occupied a great part of the present basin of Rieti (Fig. 1). This lake formed due to the deposition of material of the river Velino which developed first a strong difference in level between the plains of Rieti and Terni, originally situated on the same level. Subsequently, the sediments formed a barrier of calcarean rock at the point of the confluence of the Velino and the river Nera (Fig. 2). This barrier blocked the passage of the water of the former, and caused the flooding of the whole valley creating a lake named by the Romans Lacus Velinus.

In the Roman period, the consul Manius Curius Dentatus proceeded to a first act of reclamation of the territory and realized in 271 BC a drainage canal, called "Cavus Curianus" which allowed the water of the Velino to merge with the river Nera. It cut the barrier of calcarean rock near the locality "Marmore" and created in this way the homonymous waterfall. During the following centuries, the drainage of the lake and the reclamation of land went on in order to avoid floodings and to increase the agricultural surface. This produced a gradual fragmentation of the original lake basin. Nowadays, some separate water basins only are left: the Lago di Piediluco in the province of Terni (Umbria) and the Lago di Ventina, Lago Ripasottile and Lago Lungo in the province of Rieti (Latium).

MATERIAL AND METHODS

In spring and summer 2015 a floristic analysis was conducted with the aim to record the vascular plants present in the studied area (only for the locality "Fiume Velino", a detailed floristic study was not conducted). The field data, in some cases unedited, were integrated, where possible, with those gathered from former studies regarding the same sites or adjacent areas (Sorgi & Fanelli, 1993; Venanzoni & Gigante, 2000).

The floristic study concerned only marginally the hydrophytes (for a closer examination see Sorgi & Fanelli, 1993; Venanzoni & Gigante, 2000).

The Auchenorrhyncha samplings were carried out in several years (1999, 2000, 2005, 2006, 2009–2012, 2015), from April to November, at 11 localities (some of them sampled more times). We applied two collection methods: a) by entomological net and aspirator, b) directly by sight of single specimens by means of the aspirator. The distribution of Auchenorrhyncha species in Italy is cited prevalently from Servadei (1967) and completed by data published later in the following papers: Alma et al. (2009a, 2009b); Carl (2008); D'Urso (1995); Guglielmino & Bückle (2007, 2008); Guglielmino et al. (2005); Mazzoni (2005); Mazzoni et al. (2001); Vidano & Arzone (1987).

The present study includes also data gathered by a degree thesis (De Santis, 2010) conducted in 2009–2010 which aimed to study the Auchenorrhyncha populations of the Natural Reserve "Laghi Lungo e Ripasottile" from a faunistic point of view.

Investigated areas (Fig. 3, Table 1)

The Lago di Ventina (Figs. 4–7), part of the comunity of Colli sul Velino, is a small lake of about 10 ha, surrounded by a continuous band of helophytes.

Its flora is well preserved and very various with ca. 400 recorded species, some of which of elevated scientific interest as *Ranunculus lingua* and *Glyceria maxima*, known in Latium only in this area (Sorgi & Fanelli, 1993; Anzalone et al., 2010). The lake is bordered by pasture areas crossed by numerous ditches and surrounded by different species of willows (e.g. *Salix alba*, *S. cinerea*, *S. purpurea*) and poplars (*Populus alba* and *P. canadensis*). Presently, the lake basin and the moist areas surrounding it constitute a Site of Community Interest (pSIC) "Lago di Ventina - cod. Natura 2000 - IT6020010" because of the preserved high floristic and faunistic biodiversity.

- The Lago di Piediluco (Figs. 8, 9), including a Site of Community Interest (pSIC) (Lago di Piediluco - Monte Caperno - cod. Natura 2000 - IT5220018) and a Special Protection Zone (SPZ) (Lago di Piediluco - Monte Maro - cod. Natura 2000 - IT5220026), forms together with the "Parco fluviale del Nera" and the "Cascate delle Marmore", a part of the system of protected areas of the region of Umbria which preserves habitats of community interest. It is the largest of the residual basins of the ancient Lacus Velinus, has an irregular shape with a perimeter of about 13 km and is surrounded by wooded areas and mountains. The area stands out for the diversity of habitats and for an interesting and rich flora and fauna.

- East of the Lago di Piediluco, near the locality Madonna della Luce (Figs. 10, 11), we studied a further habitat consisting of ditches, moist meadows, shrubs of *Salix cinerea* and adjacent fields and hedges.

- Presently, the Lago Lungo (Figs. 12, 13) and Lago Ripasottile (Figs. 14, 15) constitute the "Riserva Naturale dei Laghi Lungo e Ripasottile".

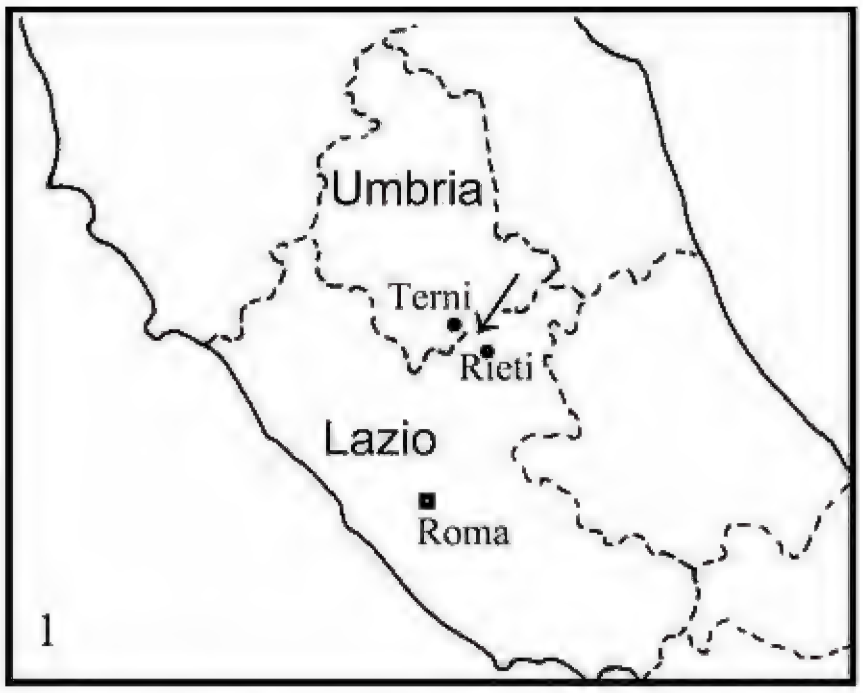
It was established in 1985 due to its exceptional avifaunistic and geographic value, and represents one of the few moist habitats in good conservation stage in Italy. On the base of the presence of many species of community interest in according to the Birds Directive 79/409 EEC and of priority habitats in according to the Habitats Directive 92/43 EEC, a part of the plain of Rieti was designated as pSIC and SPZ with the code Natura 2000 - IT6020011 "Laghi Lungo e Ripasottile".

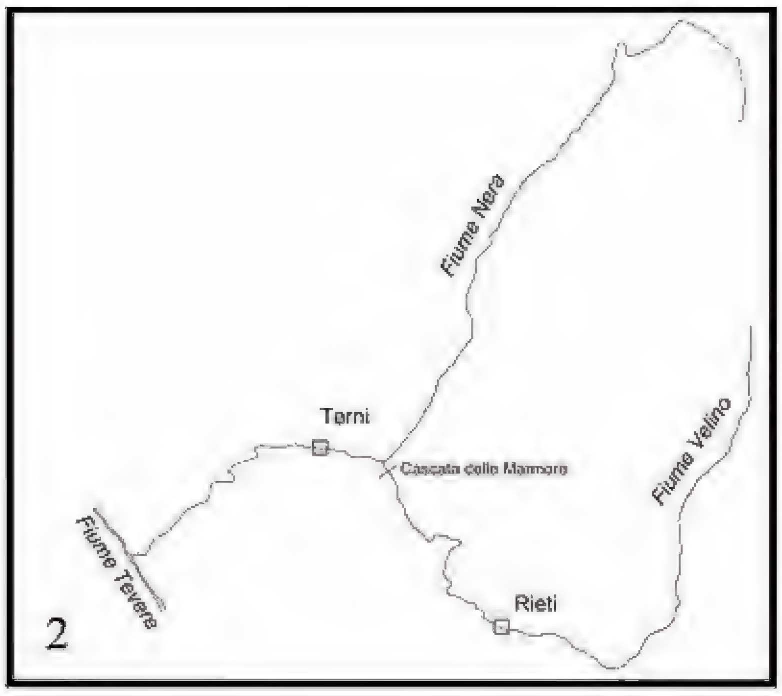
- In addition, we studied two areas near Montisola, a little village belonging to the community of Consigliano (province of Rieti): one of them (on the eastern side of the village) with ruderal vegetation near a little pond (Fig. 16), the other one (northwest of the village) consisting of a moist meadow with *Bolboschoenus maritimus* and *Carex hirta* (Fig. 17).

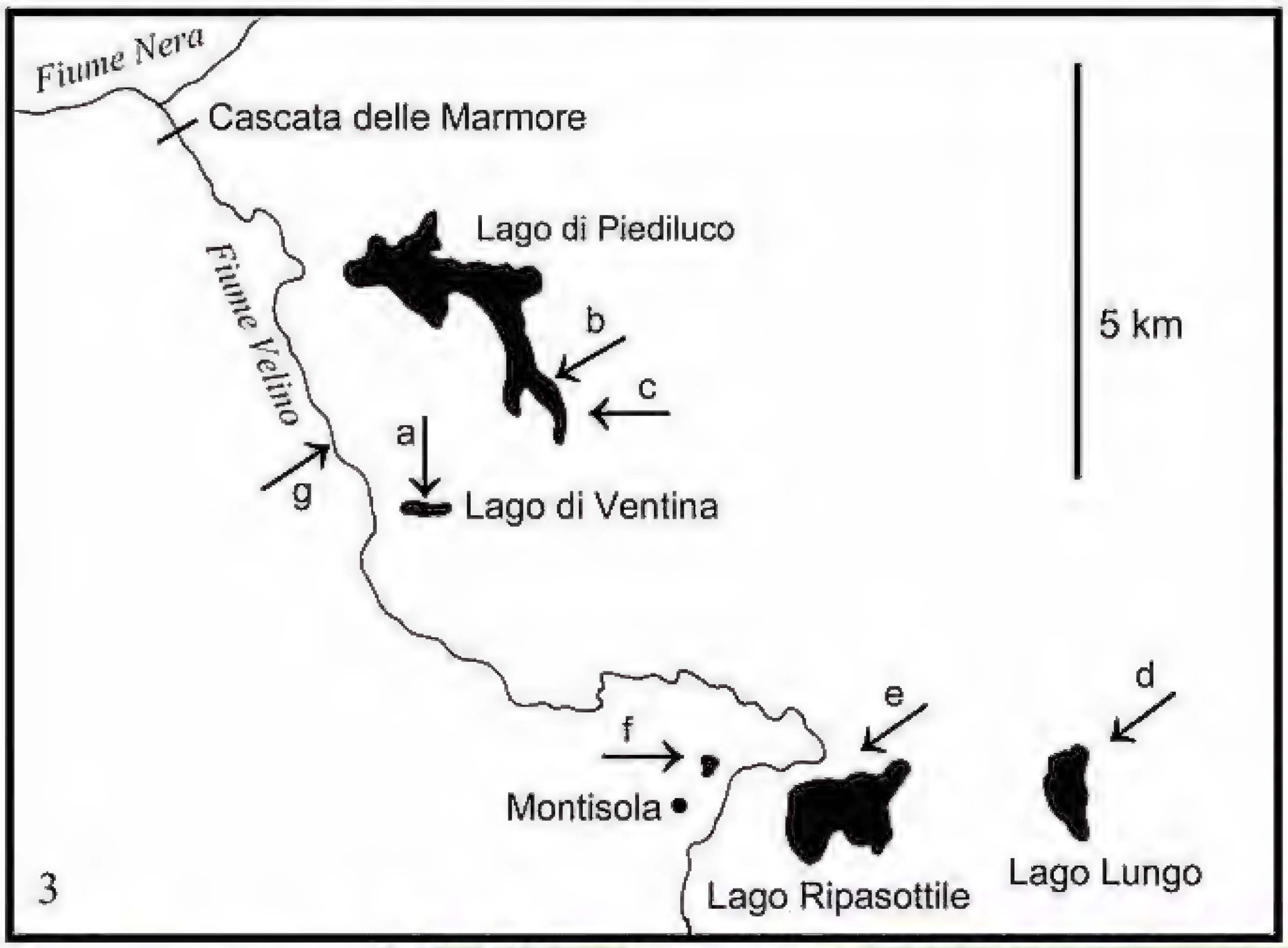
- Finally, we investigated one area on the river Velino, north of Pié di Moggio, in the province of Terni (Figs. 18, 19) with riparian vegetation (*Populus alba*, *Salix alba*, *Petasites hybridus*, Poaceae species).

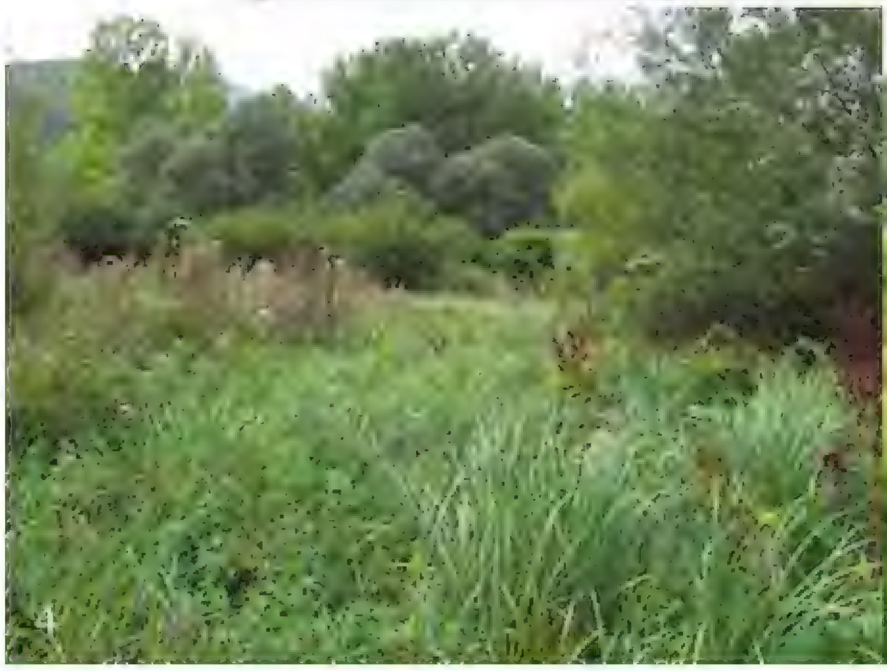
Lago di Ventina	Rieti province; Lago Ventina, southern side; N42°30'27.1" E12°45'05.0"; 375 m	26/06/2010 (loc. 543)
	Rieti province; Lago Ventina, northwestern side; N42°30'38.5" E12°44'57.5"; 378 m	26/06/2010 (loc. 544), 18/07/2011 (loc. 601), 27/04/2012 (loc. 632), 06/06/2015 (loc. 747)
	Rieti province; Lago Ventina, southwestern side; N42°30'23.0" E12°44'50.5"; 375 m	26/06/2010 (loc. 545), 30/10/2010 (loc. 549), 25/11/2011 (loc. 618), 27/04/2012 (loc. 631), 11/08/2012 (loc. 685), 06/06/2015 (loc. 746), 13/09/2015 (loc. 758)
	Rieti province; Lago Ventina, eastern side; N42°30'31.6" E12°45'39.3"; 369 m	19/09/2015 (loc. 762)
Lago di Piediluco	Terni province; Lago di Piediluco, between Piediluco and Madonna della Luce, west of road SS 79, Km 28.6; N42°31'36.8" E12°46'10.9"; 372 m	20/08/1999 (loc. 32), 22/08/2000 (loc. 87), 10/06/2005 (loc. 131, 132), 11/06/2005 (loc. 133), 13/06/2015 (loc. 748)
Madonna della Luce	Rieti province; East of Lago di Piediluco, Madonna della Luce, SS 79 near fork Labro, Km 29.5; N42°31'15.0" E12°46'38.2"; 372 m	21/08/2000 (loc. 86), 11/06/2005 (loc. 134), 13/06/2015 (loc. 749), 13/09/2015 (loc. 759)
Lago Lungo	Rieti province; Lago Lungo, N42°28'53.3" E12°51'10.1"; 376 m	25/05/2009, 15/06/2009 (loc. 452), 22/07/2009 (loc. 454), 18/08/2009, 4/09/2009, 6/11/2010 (loc. 550)
	Rieti province; Lago Lungo; N42°28'57.7" E12°51'10.9"; 372 m	19/06/2015 (loc. 750), 13/09/2015 (loc. 760)
Lago Ripasottile	Rieti province; Lago Ripasottile; N42°28'50.0" E12°49'08.0"; 371 m	25/05/2009, 15/06/2009 (loc. 451), 22/07/2009 (loc. 455), 03/08/2009, 04/09/2009
	Rieti province; Lago Ripasottile; N42°28'57.9" E12°49'08.3"; 370 m	19/06/2015 (loc. 751), 13/09/2015 (loc. 761)
Montisola	Rieti province; Montisola, pond southeast of the village; N42°28'36.8" E12°47'48.9"; 377 m	03/08/2009, 18/07/2011 (loc. 600), 27/04/2012 (loc. 630), 19/09/2015 (loc. 764)
	Rieti province; Montisola, meadow southwest of the village; N42°28'29.7" E12°47'27.5"; 388 m	18/07/2011 (loc. 602), 19/09/2015 (loc. 763)
Fiume Velino	Terni province; SS 79 between Marmore and Rieti, river Velino near Pié di Moggio, km 23.9; N42°30'50.3" E12°44'27.0"; 371 m	06/08/2006 (loc. 281)

Table 1. List of collecting sites. In order to facilitate the comparison of data in our different papers on the Italian Auchenorrhyncha fauna we maintain the number system of collecting localities applied already in other publications.


Umbria
Terni
Rieti
Lazio
Roma
1


Fiume Nera
Terni
Cascata delle Marmore
Fiume Velino
Fiume Tevere
Rieti
2


Fiume Nera
Cascata delle Marmore
Lago di Piediluco
Fiume Velino
b
c
a
g
Lago di Ventina
5 km
f
e
d
Montisola
Lago Ripasottile
Lago Lungo
3



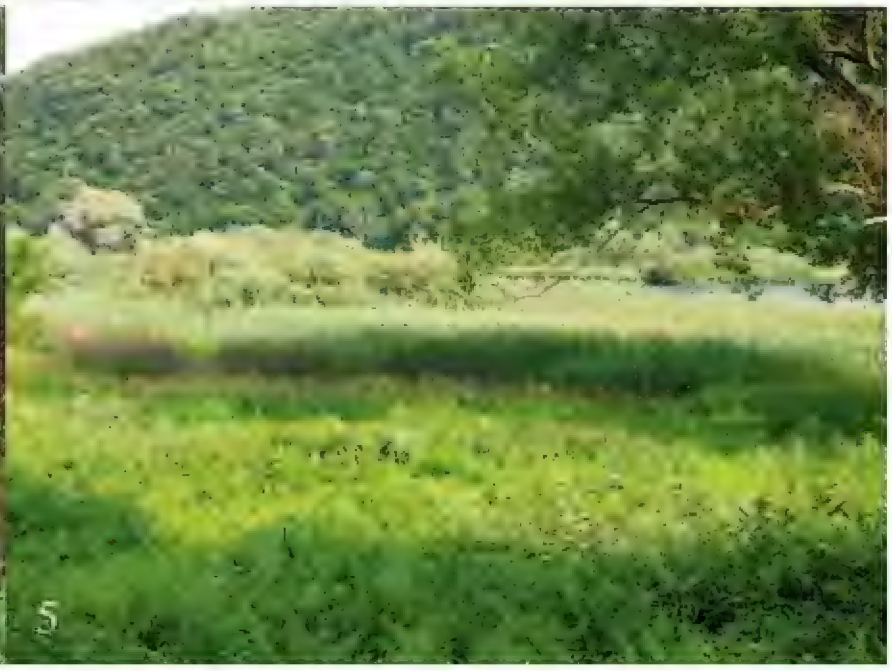
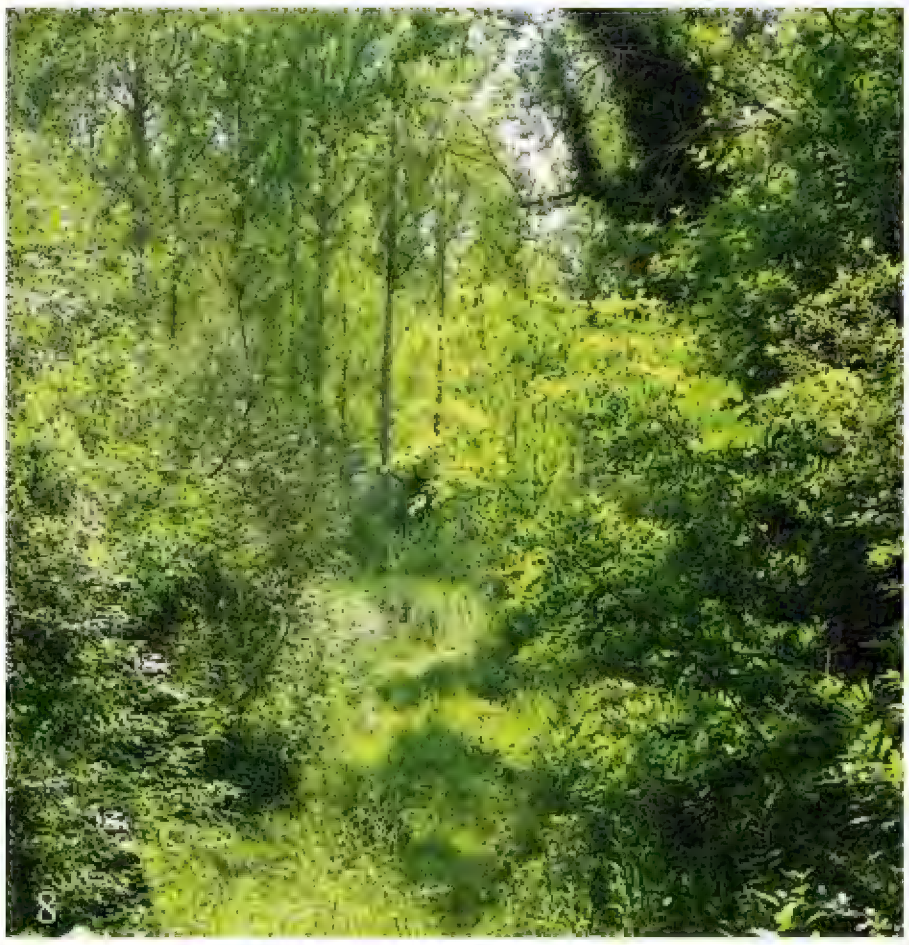


Figure 1. Outline map of Central Italy (the arrow indicates the investigated area). Figure 2. The Nera-Velino river system. Figure 3. Investigated areas. a = Lago di Ventina; b = Lago di Piediluco; c = Madonna della Luce; d = Lago Lungo; e = Lago Ripasottile; f = Montisola; g = Fiume Velino. Figures 4, 5. Lago di Ventina. Figure 4. Area east of the lake with tall sedges, willows and poplars. Figure 5. Area on the northwestern side with *Glyceria maxima*, *Phragmites australis* and *Schoenoplectus lacustris*.



Figures 6, 7. Lago di Ventina. Fig. 6: meadow on the southwestern side with *Carex hirta* and *C. distans*. Fig. 7. reed and tall sedges on the southwestern side. Figures 8, 9. Lago di Piediluco. Fig. 8: small path with different Cyperaceae and Poaceae species between willow trees. Fig. 9: undergrowth among young *Populus canadensis* trees. Figures 10, 11. Madonna della Luce. Fig. 10: moist meadow with *Carex* spp. and *Juncus* sp. along a ditch. Fig. 11: moist meadow with tall sedges, in the background *Salix cinerea*.

Figures 12, 13. Lago Lungo. Fig. 12: path along a ditch with tall sedges, *Glyceria* sp. and other Poaceae. Fig. 13: mown meadow with *Cyperus longus* and *Carex hirta*, in the background *Salix alba*. Figures 14, 15. Lago Ripasottile. Fig 14: moist meadows, ditches with sedges, reed, *Juncus* sp. and willows. Fig. 15: moist meadows with sedges, reed, *Cyperus longus*; in the background *Salix alba* and *S. cinerea*. Figures 16, 17. Montisola. Fig. 16: little pond east of the village with *Schoenoplectus lacustris* and *Phalaris arundinacea*. Fig. 17: moist meadow northwest of the village with *Carex hirta* and *Bolboschoenus maritimus*.

Figures 18, 19. Fiume Velino. Willows on the riverbanks. Figure 20. *Ranunculus lingua*. Figure 21. *Butomus umbellatus*. Figure 22. *Glyceria maxima*. Figure 23. *Carex riparia.* Photos 4–19: Christoph Bückle, 20–23 Enrico Scarici.

RESULTS

A) Flora (Table 2)

267 taxa of vascular plants have been identified belonging to 252 species, 181 genera and 57 families. The botanic nomenclature applied is the one proposed by Conti et al., 2005. The list of taxa is given in Table 2.

The florula is characterized by a significant number of remarkable taxa, characteristic of well structured and preserved moist environments, nowadays everywhere rarer and rarer. Some taxa are of particular interest as they are included in the Regional Red Lists of Italian Plants of Umbria and Latium (Conti et al., 1997). This is the case with *Carex acutiformis*, *C. elata*, *Epipactis palustris*, *Orchis incarnata*, endangered units in Umbria or with *Ranunculus lingua* (Fig. 20), *Butomus umbellatus* (Fig. 21), *Glyceria maxima* (Fig. 22), considered vulnerable in Latium. *Oenanthe aquatica* is a very rare species in Umbria and in Latium, and is considered in these regions endangered and at lower risk, respectively. Some species are also rare or very rare. They are in progressive rarefaction due to changes of the terrestrial particularly fragile humid environments. In this context may be mentioned, among others, the extremely rare species *Ranunculus lingua* and *Glyceria maxima*, present in Latium exclusively in the "Lacus Velinus" area, furthermore *Carex pseudocyperus*, *Hydrocharis morsus-ranae*, *Rorippa amphibia* and *Scutellaria galericulata*, uncommon or rare species in Latium, in addition considered at lower risk (Anzalone et al., 2010). *Frangula alnus* is regarded as rare and vulnerable in Umbria (Orsomando et al., 1998).

However, there are numerous synanthropic species as well, infesting cultures or bound to pasture and to other human activities conducted in the investigated area or in immediately adjacent zones.

In addition, we record 10 alien and invasive species with vast distribution: *Ailanthus altissima*, *Amaranthus deflexus*, *A. retroflexus*, *Artemisia verlotiorum*, *Datura stramonium*, *Erigeron canadensis*, *E. sumatrensis*, *Robinia pseudoacacia*, *Sorghum halepense* and *Xanthium orientale* subsp. *italicum* (Celesti-Grapow et al., 2010).

B) Auchenorrhyncha (Table 3)

162 species of Auchenorrhyncha have been identified belonging to 101 genera and 10 families. 60 species have host plants strictly connected with humid conditions. The list of species is given in Table 3.

Auchenorrhyncha fauna of the individual investigated areas

1) Lago di Ventina (83 species; months: IV, VI, VII, VIII, IX, X, XI)

Auchenorrhyncha species of particular interest are *Kelisia punctulum* (on *Carex acutiformis*?), *Anakelisia fasciata* (quite abundant, probably on *Carex riparia*, Fig. 23), *Megamelus notula* (on tall sedges), *Megamelodes lequesnei* (on *Carex* sp.?), *Delphacodes mulsanti* (on Cyperaceae species: *Eleocharis*?, *Cyperus*?), *Struebingianella lugubrina* (a rich population on *Glyceria maxima*), *Stroggylocephalus agrestis* (on *Carex* spp.), *Zygina lunaris* (on *Salix* sp.), *Cicadula placida* (very abundant, on *Phalaris arundinacea*, *Glyceria maxima* [and other Poaceae species ?]), and *Metalimnus formosus* (on *Carex* spp.).

Many of the species (36) found in this area are bound to humid sites. This group includes (in addition to all the taxa mentioned above) *Cixius wagneri* (on *Salix* spp.?), *Kelisia ribauti* (on *Carex* spp.), *Flastena fumipennis* (on *Cyperus longus*), and *Cicadula quadrinotata* (on *Carex* spp.), which all occur in high abundance, furthermore *Kelisia guttula* (on *Carex flacca*), *K. melanops* (on *Carex* sp.), *Stenocranus major* (on *Phalaris arundinacea*), *Conomelus lorifer dehneli* (on *Juncus* spp.), *Florodelphax leptosoma* (on *Juncus* spp.), *Javesella dubia* (on *Agrostis* sp.?), *Macropsis albae* (on *Salix alba*), *M. cerea* (on *Salix* sp.), *M. marginata* (on *Salix purpurea*), *Idiocerus stigmaticalis* (on *Salix alba*), *I. vicinus* (on *Salix cinerea*), T*remulicerus distinguendus* (on *Populus alba)*, *Viridicerus ustulatus* (on *Populus alba*), *Cicadella viridis* (on *Carex* spp.), *Notus italicus* (on *Carex paniculata*), *Edwardsiana prunicola* (on *Salix* sp.), *Eupteryx thoulessi* (on *Mentha aquatica*), *Zygina lunaris* (on *Salix* sp.), *Z. nivea* (on *Populus alba*), *Balclutha nicolasi* (on *Cyperus longus)*, *Cicadula lineatopunctata* (on *Carex* spp.?), and *Conosanus obsoletus* (on *Juncus* spp.).

Other taxa are rather euryecous and are generally found on meadows or ruderal places without specific characteristics. We mention here only some particularly abundant species as *Laodelphax striatella*, *Toya propinqua*, *Philaenus spumarius*, *Megophthalmus scanicus*, *Anaceratagallia laevis*, *A. ribauti*, *Aphrodes bicincta*, *Eupteryx atropunctata*, *E. melissae*, *Zyginidia* gr. *ribauti*, *Balclutha punctata*, *Macrosteles sexnotatus*, *M. viridigriseus*, *Deltocephalus pulicaris*, *Euscelis incisus*, *Psammotettix alienus*, *P. confinis*, *Jassargus bisubulatus*, and *Arthaldeus striifrons*.

2) Lago di Piediluco (89 species; months: VI, VIII)

Kelisia punctulum and *Cicadula placida* (on *Phalaris arundinacea*, *Glyceria maxima* [and other Poaceae species?]), can be mentioned as particularly interesting Auchenorrhyncha species.

There is a high number (31) of taxa with host plants correlated with moist or wet conditions. In addition to *Kelisia punctulum* and *Cicadula placida*, we mention *Cixius wagneri* (on *Salix* spp.?), *Kelisia brucki* (on *Juncus* spp.), *K. guttula* (on *Carex flacca*), *K. melanops* (on *Carex* sp.), *K. ribauti* (on *Carex* spp.), *Conomelus lorifer dehneli* (on *Juncus* spp.), *Delphax ribautianus* (on *Phragmites australis*), *Florodelphax leptosoma* (on *Juncus* spp.), *Javesella dubia* (on *Agrostis* sp.?), *Flastena fumipennis* (on *Cyperus longus*), *Aphrophora pectoralis* (on *Salix* spp.), *Macropsis albae* (on *Salix alba*), *M. marginata* (on *Salix purpurea*), *M. najas* (on *Salix alba*), *M. notata* (on *Salix triandra*?), *M. vicina* (on *Populus alba*), *Idiocerus stigmaticalis* (on *Salix alba*), *I. vicinus* (on *Salix purpurea*), *Metidiocerus rutilans* (on *Salix* sp.), *Viridicerus ustulatus* (on *Populus alba*), *Cicadella viridis* (on *Carex* spp.), *Kybos rufescens* (on *Salix purpurea*), *Edwardsiana prunicola* (on *Salix* spp.), *E. salicicola* (on *Salix* spp.), *Balclutha nicolasi* (on *Cyperus longus*), *Macrosteles frontalis* (on *Equisetum* sp.), *Cicadula quadrinotata* (on *Carex* spp.), *Conosanus obsoletus* (on *Juncus* spp.), and *Paralimnus phragmitis* (on *Phragmites australis*).

Out of the group of taxa of meadows or ruderal places without close connexion to wet sites we mention only the most abundant ones: *Laodelphax striatella*, *Toya propinqua*, *Dictyophara europaea*, *Trypetimorpha occidentalis*, *Cercopis vulnerata*, *Philaenus spumarius*, *Stictocephala bisonia*, *Anaceratagallia laevis*, *Austroagallia sinuata*, *Alebra wahlbergi*, *Empoasca decipiens*, *Zyginidia* gr. *ribauti*, *Macrosteles laevis*, *Allygidius abbreviatus*, *Psammotettix alienus*, *P. confinis*, *Jassargus bisubulatus*, and *Arthaldeus striifrons*.

3) Madonna della Luce (65 species; months: VI, VIII, IX)

Interesting Auchenorrhyncha species are *Cixius remotus*, *Kelisia punctulum* (a rich population, on tall *Carex* (*C. acutiformis*?), *Anakelisia fasciata* (on *Carex riparia*), *Delphacodes mulsanti* (a rich population, possibly on *Eleocharis*), *Cicadula frontalis* (on tall sedges, probably *Carex riparia*), and *C. placida* (on *Phalaris arundinacea*, *Glyceria maxima* [and other Poaceae species?]).

20 taxa have host plants correlated with moist or wet conditions. In addition to the species already mentioned before except for *C. remotus*, we record *Kelisia ribauti* (on *Carex* spp.), *Florodelphax leptosoma* (on *Juncus* spp.), *Flastena fumipennis* (on *Cyperus longus*), *Macropsis prasina* (on *Salix cinerea*), *Cicadella viridis* (on *Carex* spp.), *Asymmetrasca decedens* (on *Salix* spp.), *Edwardsiana prunicola* (on *Salix* spp.), *E. salicicola* (on *Salix* spp.), *Linnavuoriana sexmaculata* (on *Salix* spp.), *Balclutha nicolasi* (on *Cyperus longus*), *Macrosteles ossiannilssoni* (on *Carex* spp.), *M. sardus* (on *Epilobium hirsutum*), *Cicadula lineatopunctata* (on *Carex* spp.?), *C. quadrinotata* (on *Carex* spp.), and *Paralimnus phragmitis* (on *Phragmites australis*).

Among the other taxa we mention here only some particularly abundant species as *Laodelphax striatella*, *Dicranotropis remaniaca*, *Toya propinqua*, *Philaenus spumarius*, *Megophthalmus scanicus*, *Anaceratagallia laevis*, *A. ribauti*, *Aphrodes bicincta*, *Zyginidia* gr. *ribauti*, *Euscelis incisus*, *Psammotettix alienus*, *P. confinis*, and *Arthaldeus striifrons*.

4) Lago Lungo (61 species; months: V, VI, VII, VIII, IX, XI)

In this area several particularly interesting taxa were found: *Kelisia punctulum* (on tall *Carex* species [*C. acutiformis*?]), *Anakelisia fasciata* (on *Carex riparia*?), *Chloriona smaragdula* (on *Phragmites australis*), *Megamelodes lequesnei* (on *Carex* sp., probably *C. hirta*), *Delphacodes mulsanti* (on *Eleocharis*?, *Cyperus* sp.?), *Ribautodelphax albostriata* (on *Poa pratensis*), *Zygina lunaris* (on *Salix* spp.), *Z.* cf. *ordinaria* (on *Salix* spp.), and *Cicadula placida* (on *Phalaris arundinacea*, *Glyceria maxima* [and other Poaceae species?]).

26 species display an ecological restriction to moist areas. Besides the species mentioned above (with the exception of *Ribautodelphax albostriata*), the following taxa belong to this group: *Kelisia ribauti* (on *Carex* spp.), *Stenocranus major* (on *Phalaris arundinacea*), *Conomelus lorifer dehneli* (on tall *Juncus* species), *Delphax* sp. (on *Phragmites australis*), *Javesella dubia* (on *Agrostis* sp.?), *Flastena fumipennis* (on *Cyperus longus*), *Macropsis albae* (on *Salix alba*), *Idiocerus vicinus* (on *Salix purpurea*), *Stroggylocephalus agrestis* (on *Carex* spp.), *Cicadella viridis* (on *Carex* spp.), *Asymmetrasca decedens* (on *Salix* spp.), *Edwardsiana prunicola* (on *Salix* spp.), *Linnavuoriana sexmaculata* (on *Salix* spp.), *Eupteryx thoulessi* (on *Mentha aquatica*), *Balclutha nicolasi* (on *Cyperus longus*), *Cicadula quadrinotata* (on *Carex* spp.), *Conosanus obsoletus* (on *Juncus* spp.), and *Paralimnus phragmitis* (on *Phragmites australis*).

The most common taxa among the ecological generalists at this site are *Laodelphax striatella*, *Toya propinqua*, *Eupteryx atropunctata*, *Zyginidia* gr. *ribauti*, *Macrosteles laevis*, *Maiestas schmidtgeni*, *Psammotettix alienus*, *P. confinis*, and *Arthaldeus striifrons*.

5) Lago Ripasottile (76 species; months: V, VI, VII, VIII, IX)

Species of particular interest are *Kelisia praecox* (on *Carex* sp.), *K. punctulum* (on tall sedges), *Anakelisia fasciata* (on tall sedges), *Megamelus notula* (on tall sedges), *Delphacodes mulsanti* (on *Eleocharis* sp.?, *Cyperus* sp.?), *Kybos virgator* (on *Salix alba*), *Zygina* cf. *ordinaria* (on *Salix* spp.), and *Cicadula placida* (on *Phalaris arundinacea* [and other Poaceae species?]).

Including the species mentioned above, 32 taxa are correlated with moist areas: *Cixius wagneri*, *Kelisia ribauti* (on *Carex* spp.), *Stenocranus major* (on *Phalaris arundinacea*), *Chloriona unicolor* (on *Phragmites australis*), *Flastena fumipennis* (on *Cyperus longus*), *Macropsis albae* (on *Salix alba*), *M. cerea* (on *Salix* spp.), *Idiocerus stigmaticalis* (on *Salix alba*), *I. vicinus* (on *Salix purpurea*), *Populicerus albicans* (on *Populus alba*), *Viridicerus ustulatus* (on *Populus alba*), *Cicadella viridis* (on *Carex* spp.), *Kybos rufescens* (on *Salix purpurea*), *Asymmetrasca decedens* (on *Salix* spp.), *Edwardsiana prunicola* (on *Salix* spp.), *Linnavuoriana sexmaculata* (on *Salix* spp.), *Eupteryx thoulessi* (on *Mentha aquatica*), *Zygina nivea* (on *Populus alba*), *Balclutha nicolasi* (on *Cyperus longus*), *Macrosteles frontalis* (on *Equisetum* sp.), *M. sardus* (on *Epilobium hirsutum*), *Cicadula lineatopunctata* (on *Carex* sp. ?), *C. quadrinotata* (on *Carex* spp.), and *Conosanus obsoletus* (on *Juncus* spp.).

Laodelphax striatella, *Toya propinqua*, *Lepyronia coleoptrata*, *Philaenus spumarius*, *Stictocephala bisonia*, *Anaceratagallia laevis*, *Maiestas schmidtgeni*, *Psammotettix alienus*, *P. confinis* and others are generally found on meadows or ruderal places.

6) Montisola (47 species; months: IV, VII, VIII, IX)

13 taxa found in this area are typical for humid sites: *Kelisia guttula* (on *Carex flacca*), *Kelisia ribauti* (on *Carex* spp.), *Stenocranus major* (on *Phalaris arundinacea*), *Delphacodes mulsanti* (on *Eleocharis* sp.?, *Cyperus* sp.?), *Javesella dubia* (on *Agrostis* sp.?), *Idiocerus stigmaticalis* (on *Salix alba*), *Cicadella viridis* (on *Carex* spp.), *Eupteryx thoulessi* (on *Mentha aquatica*), *Macrosteles frontalis* (on *Equisetum* sp.), *M. sardus* (on *Epilobium hirsutum*), *Cicadula placida* (on *Phalaris arundinacea*, *Glyceria maxima* [and other Poaceae species?]), *C. quadrinotata* (on *Carex* spp.), and *Paramesus obtusifrons* (on *Bolboschoenus maritimus*).

Most species in this area, however, are colonizers of ruderal biotopes. The most abundant ones among them are *Laodelphax striatella*, *Agalmatium flavescens*, *Philaenus spumarius*, *Anaceratagallia laevis*, *Emelyanoviana mollicula*, *Eupteryx melissae*, *E. rostrata*, *Zyginidia* gr. *ribauti*, *Arboridia parvula*, *Neoaliturus fenestratus*, *Macrosteles laevis*, *M. sexnotatus*, *Allygidius furcatus*, *Euscelis incisus*, *Psammotettix alienus*, and *P. confinis*.

7) Fiume Velino (14 species; months: VIII)

Aphrophora salicina (on *Salix* spp.), *Macropsis albae* (on *Salix alba*), *M. vicina* (on *Populus alba*), *Viridicerus ustulatus* (on *Populus alba*), and *Zygina nivea* (on *Populus alba*) are generally found on the arboreal riverside flora. *Eupteryx petasitidis* (on *Petasites hybridus*) is often found on its host plant along rivers as well.

Dicranotropis remaniaca, *Anaceratagallia laevis* and *Eupteryx curtisii* occur in more or less shadowy and not too dry meadows.

C) Phenology (Table 4)

Auchenorrhyncha hibernate in the egg, nymph or adult stage. The last condition is rather rare. It is recorded for Central Europe among others for the genera *Asiraca* Latreille, 1796, *Stenocranus* Fieber 1866 and *Delphacodes* Fieber 1866 in Delphacidae, for Tettigometridae, for some Agalliinae and Idiocerinae, the genera *Empoasca* Walsh, 1862, *Zygina* Fieber, 1866 and *Arboridia* Zakhvatkin, 1946 in Typhlocybinae, and for the genera *Balclutha* and *Mocydiopsis* Ribaut 1939 in Deltocephalinae. Taxa that hibernate in the adult stage should be present both in advanced autumn and in spring. The data that we can gather from our present research are from 6th and 25th of November and from 27th of April, respectively. Thus, there is a gap of about five months without samplings. Of course, the insects have a reduced metabolism under winter conditions or even pass this period in some type of quiescence. In comparison to Central Europe or to mountain areas, however, this period is to be expected rather short in southern Europe and at low altitude (< 400 m). In these areas, indeed, December, March and April may offer mild weather rather than snow and frost. This implies on the one side that the late summer generation of egg overwinterers may extend until late autumn, and on the other side that nymph overwinterers reach the adult stage already in spring or early summer.

If we study the results of the seasonal distribution in our research, we find seven taxa that were collected both in late autumn and in spring: *Kelisia ribauti*, *Anakelisia fasciata*, *Stenocranus major*, *Emelyanoviana mollicula*, *Psammotettix alienus*, and *Psammotettix confinis*. For *Kelisia ribauti* and *Anakelisia fasciata*, adult overwintering is possible, but perhaps only as females. For both species only females were observed in spring with a much reduced abundance. The *Psammotettix* taxa, however, occur also in late April in rich populations including male specimens. Adult hibernation is therefore probable, in contrast to the conditions in Central Europe, where these taxa overwinter apparently in the egg stage. For *Stenocranus major* adult overwintering is probable, as the species of this genus generally hibernate in the adult stage. For *Cicadula quadrinotata* and *Emelyanoviana mollicula* we suppose equally adult overwintering. The *Cicadula* specimens (males and females) in November have apparently grown under short day conditions (strong melanism), thus they are no old summer specimens, and both sexes were found in April as well. As to *Emelyanoviana*, we found in Sardinia populations with both males and females already at the beginning of April.

Other adult overwinterers are surely among the taxa that were collected in November only, so for example the Agalliinae. Also some *Eupteryx* taxa (*E. rostrata*, *E. zelleri*) possibly hibernate in the adult stage. Particular is the case of *Megamelodes lequesnei*. This species was found exclusively in November (brachypterous males and females). Thus, this taxon has in central Italy apparently a different phenology (hibernation as adults) in respect of the central European populations (egg hibernation with two generations), in addition to a different host plant (see below).

Hibernation in the nymph stage is often observed among the Auchenorrhyncha, above all in Cixiidae, many Delphacidae, in Cercopidae and a few Deltocephalinae. Nymph overwinterers in our material are above all the taxa found in spring and early summer.

Many species collected already in April (*Eurybregma nigrolineata*, *Laodelphax striatella*, *Dicranotropis remaniaca*, *Struebingianella lugubrina*, *Xanthodelphax straminea*, *Javesella dubia*, *Ribautodelphax imitans*, *Flastena fumipennis*, *Cercopis sanguinolenta*) belong to this group, in addition to many taxa collected in June.

The third group comprises the egg overwinterers. Aphrophoridae, Macropsinae, Aphrodinae, Cicadellinae and most genera of Typhlocybinae and Deltocephalinae belong to this group. They occur generally from June to autumn. Most cicadellids in our material belong to this group.

Taxon	LV	PL	ML	LL	LR	M
Acer campestre L.	+	+				
Achillea millefolium L. s.l.	+	+	+			
Agrimonia eupatoria L. subsp. *eupatoria*	+					+
Agrostis stolonifera L.	+	+		+	+	
Ailanthus altissima (Mill.) Swingle	+					
Alisma plantago-aquatica L.	+		+			
Althaea officinalis L.	+		+	+	+	+
Amaranthus deflexus L.	+					
Amaranthus retroflexus L.				+		
Anacamptis pyramidalis (L.) Rich.		+		+		
Anagallis arvensis L. subsp. *arvensis*		+	+	+	+	
Angelica sylvestris L. subsp. *sylvestris*		+			+	
Arctium lappa L.	+	+		+	+	
Arenaria serpyllifolia L. subsp. *serpyllifolia*	+					
Artemisia verlotiorum Lamotte				+		
Artemisia vulgaris L.	+					
Atriplex prostrata Boucher ex DC.	+					
Avena barbata Pott. ex Link	+					
Avena fatua L.			+			
Avena sativa L. subsp. *sativa*	+					
Avena sterilis L.	+					
Ballota nigra L. subsp. *meridionalis* (Bég.) Bég.	+					
Bellis perennis L.	+					
Berula erecta (Huds.) Coville	+					
Bidens tripartita L. s.l.	+	+			+	
Blackstonia perfoliata (L.) Huds. subsp. *perfoliata*		+				
Bolboschoenus maritimus (L.) Palla	+					+
Brachypodium rupestre (Host) Roem. et Schult.	+	+	+			
Bromus cfr. *commutatus* Schrad.	+		+			
Bromus hordeaceus L. subsp. *hordeaceus*	+	+	+			
Bromus sterilis L.	+	+	+		+	
Butomus umbellatus L.	+					
Calystegia sepium (L.) R. Br. subsp. *sepium*	+	+	+	+	+	+
Campanula rapunculus L.	+					
Carduus pycnocephalus L. subsp. *pycnocephalus*	+					
Carex acutiformis Ehrh.	+	+		+	+	
Carex caryophyllea Latourr.		+				
Carex depauperata Curtis ex With.		+				
Carex distans L.	+	+	+			
Carex elata All. subsp. *elata*		*				
Carex flacca Schreb. subsp. *serrulata* (Biv.) Greuter		+	+			
Carex hirta L.	+	+		+	+	+
Carex otrubae Podp.	+		+			
Carex paniculata L. subsp. *paniculata*	+	*				

Table 2/1. List of vascular plant species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola. Records from bibliographic data which were not confirmed by direct observations are marked by an asterisk (*).

Taxon	LV	PL	ML	LL	LR	M
Carex pseudocyperus L.	+	+				
Carex riparia Curtis	+	+	+	+	+	
Carthamus lanatus L. subsp. *lanatus*	+					
Centaurea calcitrapa L.	+					
Centaurea soltitialis L. subsp. *soltitialis*	+					
Cephalanthera rubra (L.) Rich.		+				
Chenopodium album L. subsp. *album*				+	+	
Chenopodium polyspermum L.	+					
Chenopodium urbicum L.						+
Cerastium sp.	+	+	+			
Cichorium intybus L.	+	+	+			+
Cirsium arvense (L.) Scop.	+	+	+	+	+	+
Cirsium creticum (Lam.) d'Urv. subsp. *triumfetii* (Lacaita) Werner			+			
Cirsium vulgare (Savi) Ten.	+			+		+
Cladium mariscus (L.) Pohl		*				
Clematis vitalba L.	+	+				
Conium maculatum L. subsp. *maculatum*		+				
Convolvulus arvensis L.	+		+			+
Cornus sanguinea L. s.l.	+	+	+	+	+	+
Corylus avellana L.		+				
Cota tinctoria (L.) J. Gay subsp. *tinctoria*	+					
Crataegus monogyna Jacq.	+	+				
Crepis vesicaria L. s.l.			+			
Cruciata laevipes Opiz	+	+	+			
Cynodon dactylon (L.) Pers.	+		+	+		+
Cynoglossum creticum Mill.	+					
Cyperus longus L.	+	+	+	+	+	
Dactylis glomerata L. subsp. *glomerata*		+	+	+		
Dasypyrum villosum (L.) P. Candargy, non Borbás	+					
Datura stramonium L. subsp. *stramonium*	+					
Daucus carota L. subsp. *carota*	+	+	+	+	+	+
Digitaria sanguinalis (L.) Scop. s.l.		+		+		
Dipsacus fullonum L.	+		+			
Dorycnium herbaceus Vill.		+				
Echinocloa crus-galli (L.) P. Beauv.	+		+	+	+	+
Echium plantagineum L.	+					
Eleocharis palustris (L.) Roem. et Schult. subsp. *palustris*	+		+			+
Elymus repens (L.) Gould. subsp. *repens*	+		+	+	+	+
Epilobium hirsutum L.	+		+	+	+	+
Epipactis palustris (L.) Crantz	*	*				
Equisetum arvense L. subsp. *arvense*	+	+		+	+	+
Equisetum palustre L.	+	+				
Equisetum telmateja Ehrh.	+		+	+		
Erigeron annuus (L.) Desf. (= *Aster annuus* L.)	+					

Table 2/2. List of vascular plant species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola. Records from bibliographic data which were not confirmed by direct observations are marked by an asterisk (*).

Taxon	LV	PL	ML	LL	LR	M
Erigeron canadensis L. [= *Conyza canadensis* (L.) Cronq.]	+			+	+	
Erigeron sumatrensis Retz.	+			+		
Euonymus europaeus L.	+	+	+			+
Eupatorium cannabinum L. subsp. *cannabinum*	+	+	+	+	+	
Euphorbia platyphyllos L. s.l.	+				+	
Festuca sp.			+			
Festuca arundinacea Schreb. subsp. *arundinacea*	+	+	+	+		+
Festuca heterophylla Lam.		+				
Ficus carica L.		+				
Fragaria viridis Duchesne subsp. *viridis*	+					
Frangula alnus L.		+				
Fraxinus angustifolia Vahl subsp. *oxycarpa* (Willd.) Franco et Rocha		+				
Galega officinalis L.	+	+	+		+	+
Galium aparine L.	+	+				
Galium mollugo L. subsp. *erectum* Syme (= *G. album* Mill.)	+	+	+			+
Galium mollugo L. subsp. *mollugo*			+			
Galium palustre L. s.l.	+	+	+			+
Geranium dissectum L.	+		+	+		
Geum urbanum L.	+		+			
Glyceria fluitans (L.) R. Br.	+			+		
Glyceria maxima (Hartm.) Holmb.	+					
Hedera helix L. subsp. *helix*	+					
Heliotropium europaeum L.				+		
Helleborus foetidus L. subsp. *foetidus*			+			
Helminthotheca echioides (L.) Holub (= *Picris echioides* L.)	+		+	+		+
Holcus lanatus L.	+	+	+	+		
Hordeum murinum L. subsp. *leporinum* (Link) Arcang.	+					
Humulus lupulus L.	+	+	+	+	+	
Hydrocharis morsus-ranae L.	*					
Hypericum perforatum L.	+	+	+		+	
Hypericum tetrapterum Fr.	+			+	+	
Hypochaeris radicata L.	+					
Inula conyzae (Griess.) Meikle	+					
Iris pseudacorus L.	+	+	+	+	+	
Juncus articulatus L.	+	+	+	+		
Juncus effusus L. subsp. *effusus*	+			+	+	
Juncus gerardii Loisel.	+		+			
Juncus inflexus L.			+			
Juniperus communis L.	+	+				
Lactuca saligna L.	+					
Lactuca serriola L.	+			+	+	
Lamium maculatum L.		+				
Leucanthemum sp.	+	+	+			
Ligustrum vulgare L.	+	+				

Table 2/3. List of vascular plant species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola. Records from bibliographic data which were not confirmed by direct observations are marked by an asterisk (*).

Taxon	LV	PL	ML	LL	LR	M
Linaria vulgaris Mill. subsp. *vulgaris*	+					
Linum bienne Mill.	+	+				
Lolium multiflorum Lam. subsp. *multiflorum*	+					
Lolium perenne L.	+	+	+	+		
Lonicera caprifolium L.		+				
Lotus sp.		+				
Lotus corniculatus L. subsp. *corniculatus*	+		+			+
Lycopus europaeus L. s.l.	+	+		+	+	+
Lysimachia vulgaris L.	+	+		+	+	+
Lythrum salicaria L.	+		+	+	+	+
Malva sylvestris (L.) Mill.	+		+			
Medicago lupulina L.	+	+	+			
Medicago minima (L.) L.	+					
Medicago orbicularis (L.) Bartal.	+					
Medicago sativa L.	+		+			+
Mentha aquatica L. subsp. *aquatica*	+	+	+	+		+
Mentha arvensis L.	+		+			+
Mentha longifolia (L.) Huds.	+	+	+	+	+	+
Mentha suaveolens Ehrh. subsp. *suaveolens*	+	+				
Mercurialis annua L.					+	
Nigella damascena L.	+					
Nuphar lutea (L.) Sm.	+					
Odonthites vulgaris Moench subsp. *vulgaris*	+					+
Oenanthe aquatica (L.) Poir.	*	*				
Ophrys apifera Huds.		+				
Orchis incarnata L.	*	*				
Pallenis spinosa (L.) Cass. subsp. *spinosa*	+					
Papaver rhoeas L. subsp. *rhoeas*	+					
Paspalum distichum L.	+					
Pastinaca sativa L. subsp. *urens* (Req. ex Godr.) Celak.	+		+			+
Persicaria maculosa (L.) Gray	+			+	+	+
Petrorhagia prolifera (L.) P.W. Ball et Heywood	+					
Phalaris aquatica L.			+			
Phalaris arundinacea L. subsp. *arundinacea* [= *Typhoides arundinacea* (L.) Moench]	+	+		+	+	+
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis*	+	+	+	+	+	
Phyllostachys bambusoides Siebold et Zucc.		+				
Picris hieracioides L. subsp. *hieracioides*	+	+	+	+		+
Plantago lanceolata L.	+	+	+	+	+	+
Plantago major L. subsp. *major*	+	+	+	+	+	+
Poa bulbosa L.	+					
Poa trivialis L. subsp. *trivialis*	+	+	+			
Polygonum arenastrum Boreau subsp. *arenastrum*			+			
Polygonum aviculare L. s.l.			+	+	+	+
Populus alba L.	+	+		+		

Table 2/4. List of vascular plant species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola. Records from bibliographic data which were not confirmed by direct observations are marked by an asterisk (*).

Taxon	LV	PL	ML	LL	LR	M
Populus canadensis Moench	+	+	+			+
Populus tremula L.	+					
Potentilla reptans L.	+	+	+	+	+	+
Prunella vulgaris L. subsp. *vulgaris*	+		+			
Prunella x *intermedia* Link	+					
Prunus spinosa L. subsp. *spinosa*	+	+	+			
Pteridium aquilinum (L.) Kuhn subsp. *aquilinum*	+					
Pulicaria dysenterica (L.) Bernh.	+		+	+	+	+
Ranunculus lingua L.	+					
Ranunculus repens L.	+	+	+	+		+
Ranunculus sardous Crantz s.l.	+		+			
Ranunculus trichophyllus Chaix subsp. *trichophyllus*	+					
Raphanus raphanistrum L. subsp. *landra* (DC.) Bonnier et Layens					+	
Rhinanthus sp.		+				
Robinia pseudacacia L.	+	+				
Rorippa amphibia (L.) Besser	+					
Rosa canina s.l.	+		+			
Rosa sempervirens L.	+					
Rosa sp.		+				
Rubia peregrina L. subsp. *peregrina*		+				
Rubus caesius L.	+	+	+		+	+
Rubus sp.	+					
Rubus ulmifolius Schott	+	+				
Rumex crispus L.	+		+	+		+
Rumex hydrolapathum Huds.	+	+				
Rumex obtusifolius L. subsp. *obtusifolius*				+		+
Rumex pulcher subsp. *pulcher*			+			
Ruscus aculeatus L.		+				
Sagittaria sagittifolia L.			+			
Salix alba L.	+	+	+	+	+	+
Salix cinerea L.	+	+	+	+	+	+
Salix purpurea L. s.l.	+	+				
Salix triandra L. subsp. *amygdalina* (L.) Schübl. et G. Martens						+
Sambucus ebulus L.	+	+				
Sambucus nigra L.	+	+			+	
Sanguisorba minor Scop.subsp. *balearica* (Bourg. ex Nyman) Munoz Garm. et C. Navarro	+	+	+	+		
Schoenoplectus lacustris (L.) Palla	+	+		+		+
Scirpoides holoschoenus (L.) Sojàk			+			
Scrophularia umbrosa Dumort. subsp. *umbrosa*	+	*		+		
Scutellaria galericulata L.	+					
Securigera securidiana (L.) Degen et Dörfl.	+					
Senecio erraticus Bertol. subsp. *erraticus*	+				+	
Setaria verticillata (L.) P. Beauv.						+
Setaria viridis (L.) P. Beauv. subsp. *viridis*	+				+	

Table 2/5. List of vascular plant species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola. Records from bibliographic data which were not confirmed by direct observations are marked by an asterisk (*).

Taxon	LV	PL	ML	LL	LR	M
Sherardia arvensis L.	+					
Sideritis romana L. subsp. *romana*	+					
Silene conica L.	+					
Silene latifolia L. subsp. *alba* (Mill.) Greuter et Burdet	+	+	+	+		+
Silene vulgaris (Moench) Garcke s.l.		+	+			
Sisymbrium officinale (L.) Scop.	+					
Solanum dulcamara L.	+	+	+	+		
Solanum nigrum L.					+	
Solidago gigantea Aiton		+				
Sonchus asper (L.) Hill subsp. *asper*	+				+	
Sorghum halepense (L.) Pers.	+			+	+	+
Sparganium erectum L. subsp. *erectum*	+					
Stachys palustris L.	+	+			+	+
Stachys germanica L. subsp. *salviifolia* (Ten.) Gams.	+					
Stellaria aquatica (L.) Scop.	+					
Stellaria media Viv. subsp. *media*	+					
Taraxacum officinale s.l.	+	+	+			+
Teucrium scordium L. subsp. *scordioides* (Schreb.) Arcang.	+					
Thalictrum lucidum L.	+	+			+	+
Torilis sp.	+					
Trifolium campestre Schreb.	+					
Trifolium echinatum M. Bieb.	+					
Trifolium fragiferum L. subsp. *fragiferum*	+					
Trifolium pratense L. subsp. *pratense*	+	+	+			
Trifolium repens L. subsp. *repens*	+	+				
Trifolium resupinatum L.	+			+		
Typha angustifolia L.	+	+	+			
Typha latifolia L.			+	+		
Ulmus minor Mill. subsp. *minor*		+				
Urtica dioica L. subsp. *dioica*	+	+	+	+	+	+
Valeriana officinalis L.		+				
Valerianella sp.	+	+	+			
Verbascum blattaria L.	+					
Verbascum densiflorum Bertol.				+	+	
Verbascum cf. *pulverulentum* Vill.				+		
Verbascum sinuatum L.	+					
Verbena officinalis L.	+	+	+	+	+	+
Veronica anagallis-aquatica L. subsp. *anagallis-aquatica*	+					
Veronica arvensis L.	+					
Veronica montana L.	+					
Viburnum opulus L.		+				
Vicia hybrida L.	+					
Vicia sativa L. s.l.	+	+	+			
Vicia sativa L. subsp. *cordata* (Hoppe) Batt.	+					
Vicia sativa L. subsp. *nigra* (L.) Ehrh.	+		+			
Viola arvensis Murray s.l.	+					
Xanthium orientale L. subsp. *italicum* Moretti) Greuter (= *X. italicum* Moretti)	+			+	+	+

Table 2/6. List of vascular plant species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola. Records from bibliographic data which were not confirmed by direct observations are marked by an asterisk (*).

Taxon **Locality**	**LV**	**LP**	**ML**	**LL**	**LR**	**M**	**FV**
Cixius nervosus (Linnaeus, 1758)		(+)	(+)				
Cixius remotus Edwards, 1888 [1]			++				
Cixius wagneri China, 1942 [4]	+	(+)			+		
Reptalus quinquecostatus (Dufour, 1833)					+		
Hyalesthes obsoletus Signoret, 1865					+		
Kelisia brucki Fieber, 1878		++					
Kelisia guttula (Germar, 1818) [3,4]	(+)	++				+	
Kelisia melanops Fieber, 1878 [3,4]	+	++					
Kelisia praecox Haupt, 1935 [2]					(+)		
Kelisia punctulum (Kirschbaum, 1868) [1]	(+)	+	++	+	(+)		
Kelisia ribauti Wagner, 1938 [4]	++	+	++	++	+	+	
Anakelisia fasciata (Kirschbaum, 1868) [1]	++		+	(+)	+		
Stenocranus major (Kirschbaum, 1868)	+			+	(+)	++	
Eurybregma nigrolineata Scott, 1875	+						
Conomelus lorifer dehneli Nast, 1966 [4]	+	+		+			
Delphax ribautianus Asche et Drosopoulos, 1982 [4]		+					
Delphax sp.		+		+			
Chloriona smaragdula (Stål, 1853) [2]				++			
Chloriona unicolor (Herrich-Schäffer, 1835)					(+)		
Megamelus notula (Germar, , 1830) [3]	+				(+)		
Laodelphax striatella (Fallén, 1826)	++	++	+	++	++	+	
Megamelodes lequesnei Wagner, 1963 [1]	(+)			+			
Delphacodes mulsanti (Fieber, 1866) [3]	+		++	(+)	+	(+)	
Muirodelphax aubei (Perris, 1857) [4]		(+)	+				
Dicranotropis remaniaca Guglielmino, D'Urso et Bückle, 2016	(+)		++	+	+	(+)	+
Florodelphax leptosoma (Flor, 1861) [4]	++	+	+				
Struebingianella lugubrina (Boheman, 1847) [2]	++						
Xanthodelphax straminea (Stål, 1858) [4]	+	+					
Toya propinqua (Fieber, 1866)	+	++	++	++	++	(+)	
Javesella dubia (Kirschbaum, 1868) [4]	+	+		+		(+)	
Ribautodelphax albostriata (Fieber, 1866) [3]				+			
Ribautodelphax imitans (Ribaut, 1953) [4]	+	(+)	+				
Flastena fumipennis (Fieber, 1866) [4]	++	+	+	+	+		
Neomenocria advena (Spinola , 1839) [3]	+						
Dictyophara europaea (Linnaeus, 1767)		+		(+)	+	(+)	
Trypetimorpha occidentalis Huang et Bourgoin, 1993		+					
Agalmatium flavescens (Olivier, 1791)						+	
Issus coleoptratus (Fabricius, 1781)		+					(+)
Cercopis arcuata (Fieber, 1844)				(+)	(+)		
Cercopis sanguinolenta (Scopoli, 1763)	(+)						
Cercopis vulnerata Rossi, 1807	+	+	(+)				

Table 3/1. List of collected Auchenorrhyncha species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola; FV = Fiume Velino; 1 = new for Italy; 2 = new for peninsular Italy; 3 = new for Latium; 4 = new for Umbria.

Taxon **Locality**	**LV**	**LP**	**ML**	**LL**	**LR**	**M**	**FV**
Lepyronia coleoptrata (Linnaeus, 1758)	+	+		+	++	(+)	
Neophilaenus campestris (Fallén, 1805)		+					
Aphrophora alni (Fallén, 1805)	+	+					
Aphrophora pectoralis Matsumura, 1903 [4]		+					
Aphrophora salicina (Goeze, 1778)							+
Philaenus spumarius (Linnaeus, 1758)	+	+	+	+	++	+	
Centrotus cornutus (Linnaeus, 1758)		(+)					
Stictocephala bisonia Kopp et Yonke, 1977 [4]	+	+	(+)	+	++	(+)	
Megophthalmus scanicus (Fallén, 1806)	++	+	+	(+)	(+)		
Macropsis albae Wagner, 1950 [4]	+	+		++	+		+
Macropsis cerea (Germar, 1837)	+				(+)		
Macropsis glandacea (Fieber, 1868) [4]		(+)					
Macropsis marginata (Herrich-Schäffer, 1836)	+	+					
Macropsis najas Nast, 1981 [4]		+					
Macropsis notata (Prohaska, 1923) [4]		+					
Macropsis prasina (Boheman, 1852) [3]			+				
Macropsis vicina Horváth, 1897 [4]		+					+
Hephathus nanus (Herrich-Schäffer, 1835)			(+)				
Anaceratagallia laevis (Ribaut, 1935)	+	++	+	+	++	+	+
Anaceratagallia ribauti (Ossiannilsson, 1938)	+	+	+	+	+	+	
Austroagallia sinuata (Mulsant et Rey, 1855)		+	+		+		
Idiocerus stigmaticalis Lewis, 1834 [4]	+	(+)			+	(+)	
Idiocerus vicinus Melichar, 1898 [4]	(+)	(+)		+	+		
Balcanocerus larvatus (Herrich-Schäffer, 1835)			+				
Metidiocerus rutilans (Kirschbaum, 1868) [4]		+					
Populicerus albicans (Kirschbaum, 1868)					+		
Tremulicerus distinguendus (Kirschbaum, 1868)	(+)						
Viridicerus ustulatus (Mulsant et Rey, 1855)	(+)	+			+		(+)
Iassus scutellaris (Fieber, 1868)		+	+				
Penthimia nigra (Goeze, 1778)		(+)					
Eupelix cuspidata (Fabricius, 1775) [4]	(+)	(+)			(+)	(+)	
Aphrodes bicincta (Schrank, 1776)	+		+		+		
Aphrodes makarovi Zachvatkin, 1948	+	+	(+)				
Anoscopus albifrons mappus Guglielmino et Bückle, 2015			(+)				
Anoscopus serratulae (Fabricius, 1775)	(+)						
Stroggylocephalus agrestis (Fallén, 1806)	(+)			(+)			
Evacanthus acuminatus (Fabricius, 1794)		+					
Cicadella viridis (Linnaeus, 1758)	+	+	+	++	++	+	
Alebra wahlbergi (Boheman, 1845)	(+)	+	++				
Emelyanoviana mollicula (Boheman, 1845)	+	+	(+)	+	+	+	

Table 3/2. List of collected Auchenorrhyncha species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola; FV = Fiume Velino; 1 = new for Italy; 2 = new for peninsular Italy; 3 = new for Latium; 4 = new for Umbria.

Taxon Locality	**LV**	**LP**	**ML**	**LL**	**LR**	**M**	**FV**
Dikraneura variata Hardy, 1850			(+)				
Wagneriala sinuata (Then , 1897) 4	(+)	+					
Notus italicus Wagner, 1954 3	++						
Kybos rufescens Melichar, 1896 4		+			(+)		
Kybos virgator (Ribaut, 1933) 3					(+)		
Empoasca decipiens Paoli, 1930		++	(+)	+	+	+	
Empoasca pteridis (Dahlbom , 1850)		+			+		
Empoasca vitis (Göthe, 1875)				(+)	+		
Empoasca sp.	(+)	+		+	+	(+)	
Asymmetrasca decedens Paoli, 1932 3			(+)	+	+		
Edwardsiana diversa (Edwards, 1914)		(+)					
Edwardsiana prunicola (Edwards, 1914) 4	+	+	+	(+)	+		
Edwardsiana salicicola (Edwards, 1885) 4		+	+				
Edwardsiana sp.	(+)	+		(+)	+		
Linnavuoriana sexmaculata (Hardy, 1850)			+	+	(+)		
Ribautiana cruciata Ribaut, 1931			+				
Ribautiana debilis (Douglas, 1876) 3			(+)				
Ribautiana tenerrima (Herrich-Schäffer, 1834) 4		+					
Eupteryx atropunctata (Goeze, 1778)	+			++	++	+	(+)
Eupteryx curtisii (Flor, 1861)	+	+		+			+
Eupteryx decemnotata Rey, 1891 3						(+)	
Eupteryx melissae Curtis, 1837 4	++	+		+	(+)	+	
Eupteryx notata Curtis, 1837 3	(+)					(+)	
Eupteryx petasitidis Ferrari, 1882 4							++
Eupteryx rostrata Ribaut, 1936 4	+	+		(+)	(+)	+	
Eupteryx thoulessi Edwards, 1926	+			++	+	+	
Eupteryx urticae (Fabricius, 1803)	(+)				(+)		
Eupteryx zelleri (Kirschbaum, 1868)	+	+		+	+	(+)	
Zyginidia gr. *ribauti* Dworakowska, 1970	+	++	+	++	+	+	
Zygina discolor Horváth, 1897 4		(+)	+				
Zygina lunaris (Mulsant et Rey, 1855) 3	(+)			+	(+)		
Zygina nivea (Mulsant et Rey, 1855) 3,4	(+)				+		+
Zygina cf. *ordinaria* (Ribaut, 1936) 3				+	+		
Arboridia parvula (Boheman, 1845)		(+)			+	+	
Arboridia spathulata (Ribaut, 1931)			(+)				
Arboridia sp.		(+)			(+)		
Fruticidia bisignata (Mulsant et Rey, 1855)						(+)	
Goniagnathus brevis (Herrich-Schäffer, 1835)		+			+		
Hishimonus cf. *hamatus* Kuoh, 1976 2			(+)		(+)		
Neoaliturus fenestratus (Herrich-Schäffer, 1834)			+		+	+	(+)
Balclutha nicolasi (Lethierry, 1876) 4	+	++	++	+	++		
Balclutha punctata (Fabricius, 1775)	++	+					

Table 3/3. List of collected Auchenorrhyncha species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola; FV = Fiume Velino; 1 = new for Italy; 2 = new for peninsular Italy; 3 = new for Latium; 4 = new for Umbria.

Taxon **Locality**	**LV**	**LP**	**ML**	**LL**	**LR**	**M**	**FV**
Balclutha rosea (Scott, 1876)					+		
Balclutha saltuella (Kischbaum, 1868)					(+)		
Macrosteles forficula (Ribaut, 1927)						(+)	
Macrosteles frontalis (Scott, 1875) [4]		++			+	+	
Macrosteles laevis (Ribaut, 1927)	(+)	++		++	+	++	(+)
Macrosteles ossiannilssoni Lindberg, 1954			(+)				
Macrosteles quadripunctulatus (Kirschbaum, 1868) [4]		+					
Macrosteles sardus Ribaut, 1948			(+)		+	+	
Macrosteles sexnotatus (Fallén, 1806)	+		(+)	(+)		++	
Macrosteles viridigriseus (Edwards, 1924) [4]	+	+		(+)		+	
Macrosteles sp.	+	+	+	++	(+)	++	
Deltocephalus pulicaris (Fallén, 1806)	+				+	+	
Maiestas schmidtgeni (Wagner, 1939)	+	+	+	++	++		
Chiasmus conspurcatus (Perris, 1857)	(+)	+		+	+		
Doratura paludosa Melichar, 1897				+			
Phlogotettix cyclops (Mulsant et Rey, 1855) [4]		(+)					
Exitianus taeniaticeps (Kirschbaum, 1868)	(+)						
Anoplotettix fuscovenosus (Ferrari, 1882)			+				
Lamprotettix nitidulus (Fabricius, 1787)	(+)						
Allygus modestus Scott, 1876 [4]		+					
Allygidius abbreviatus (Lethierry, 1878)		+	(+)				
Allygidius atomarius (Fabricius, 1794)			+				
Allygidius furcatus (Ferrari, 1882)						+	
Phlepsius sp.					(+)		
Graphocraerus ventralis (Fallén, 1806)		+	+	+	+		
Cicadula frontalis (Herrich-Schäffer, 1835) [3]			+				
Cicadula lineatopunctata (Matsumura, 1908)	+		+		(+)		
Cicadula placida (Horváth, 1897) [3,4]	++	++	+	+	+	++	
Cicadula quadrinotata (Fabricius, 1794) [4]	++	++	+	++	+	+	
Mocydia crocea (Herrich-Schäffer, 1837)	(+)			(+)	(+)	(+)	
Thamnotettix zelleri (Kirschbaum, 1868) [4]		(+)	+				
Conosanus obsoletus (Kirschbaum, 1858)	+	+	+	+	+		
Euscelis incisus (Kirschbaum, 1858)	+		+	+	+	+	
Euscelis lineolatus Brullé, 1832			(+)				
Euscelis sp.							(+)
Artianus manderstjernii (Kirschbaum, 1868)			(+)	+	(+)	(+)	
Paramesus obtusifrons (Stål, 1853)						+	
Paralimnus phragmitis (Boheman, 1847) [4]		+	+	+			
Metalimnus formosus (Boheman, 1845) [2]	++						
Arocephalus longiceps (Kirschbaum, 1868) [4]	(+)	+		(+)			
Psammotettix alienus (Dahlbom, 1850)	+	+	++	++	++	+	
Psammotettix confinis (Dahlbom, 1850)	++	++	++	++	++	+	
Adarrus exornatus Ribaut, 1952 [4]		+					
Jassargus bisubulatus (Then, 1896)	+	++					
Arthaldeus striifrons (Kirschbaum, 1868)	+	+	+	++			

Table 3/4. List of collected Auchenorrhyncha species and their collecting localities. LV = Lago di Ventina; LP = Lago di Piediluco; ML = Madonna della Luce; LL = Lago Lungo; LR = Lago Ripasottile; M = Montisola; FV = Fiume Velino; 1 = new for Italy; 2 = new for peninsular Italy; 3 = new for Latium; 4 = new for Umbria.

Taxon **month**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
Cixius nervosus (Linnaeus, 1758)			+		+			
Cixius remotus Edwards, 1888			+					
Cixius wagneri China, 1942			+	+		+		
Reptalus quinquecostatus (Dufour , 1833)				+	+			
Hyalesthes obsoletus Signoret, 1865				+				
Kelisia brucki Fieber, 1878			+					
Kelisia guttula (Germar, 1818)			+			+		
Kelisia melanops Fieber, 1878			+					+
Kelisia praecox Haupt, 1935						+		
Kelisia punctulum (Kirschbaum, 1868)			+			+		
Kelisia ribauti Wagner, 1938	+		+	+	+	+	+	+
Anakelisia fasciata (Kirschbaum, 1868)	+		+	+		+	+	+
Stenocranus major (Kirschbaum, 1868)	+		+	+	+	+	+	+
Eurybregma nigrolineata Scott, 1875	+							
Conomelus lorifer dehneli Nast, 1966			+	+		+		
Delphax ribautianus Asche et Drosopoulos, 1982					+			
Chloriona smaragdula (Stål, 1853)				+	+	+		
Chloriona unicolor (Herrich-Schäffer, 1835)						+		
Megamelus notula (Germar, 1830)			+			+	+	+
Laodelphax striatella (Fallén, 1826)	+		+	+	+	+		
Megamelodes lequesnei Wagner, 1963								+
Delphacodes mulsanti (Fieber, 1866)			+			+	+	+
Muirodelphax aubei (Perris, 1857)			+		+			
Dicranotropis remaniaca Guglielmino, D'Urso et Bückle, 2016	+		+	+	+			
Florodelphax leptosoma (Flor, 1861)			+		+		+	
Struebingianella lugubrina (Boheman, 1847)	+					+		
Xanthodelphax straminea (Stål, 1858)	+				+	+		
Toya propinqua (Fieber, 1866)		+	+	+	+	+		+
Javesella dubia (Kirschbaum, 1868)	+		+	+		+		
Ribautodelphax albostriata (Fieber, 1866)				+		+		
Ribautodelphax imitans (Ribaut, 1953)	+		+		+			
Flastena fumipennis (Fieber, 1866)	+		+	+	+	+		
Neomenocria advena (Spinola, 1839)			+					
Dictyophara europaea (Linnaeus, 1767)				+	+			
Trypetimorpha occidentalis Huang et Bourgoin, 1993					+			
Agalmatium flavescens (Olivier, 1791)				+				
Issus coleoptratus (Fabricius, 1781)			+		+			
Cercopis arcuata (Fieber, 1844)		+	+					
Cercopis sanguinolenta (Scopoli, 1763)	+							
Cercopis vulnerata Rossi, 1807			+					

Table 4/1. Table 4. List of Auchenorrhyncha species and their collecting months.

Taxon **month**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
Lepyronia coleoptrata (Linnaeus, 1758)			+	+	+	+		
Neophilaenus campestris (Fallén, 1805)			+					
Aphrophora alni (Fallén, 1805)			+			+		
Aphrophora pectoralis Matsumura, 1903			+					
Aphrophora salicina (Goeze, 1778)					+			
Philaenus spumarius (Linnaeus, 1758)		+	+	+	+	+	+	+
Centrotus cornutus (Linnaeus, 1758)			+					
Stictocephala bisonia Kopp et Yonke, 1977				+	+	+		
Megophthalmus scanicus (Fallén, 1806)			+			+		
Macropsis albae Wagner, 1950			+	+	+			
Macropsis cerea (Germar, 1837)			+					
Macropsis glandacea (Fieber, 1868)			+					
Macropsis marginata (Herrich-Schäffer, 1836)			+					
Macropsis najas Nast, 1981			+					
Macropsis notata (Prohaska, 1923)			+					
Macropsis prasina (Boheman, 1852)			+					
Macropsis vicina Horváth, 1897			+		+			
Hephathus nanus (Herrich-Schäffer, 1835)			+					
Anaceratagallia laevis (Ribaut, 1935)			+	+	+	+	+	+
Anaceratagallia ribauti (Ossiannilsson, 1938)			+	+	+	+	+	+
Austroagallia sinuata (Mulsant et Rey, 1855)				+	+			
Idiocerus stigmaticalis Lewis, 1834			+	+		+		
Idiocerus vicinus Melichar, 1898				+	+	+		
Balcanocerus larvatus (Herrich-Schäffer, 1835)			+					
Metidiocerus rutilans (Kirschbaum, 1868)			+					
Populicerus albicans (Kirschbaum, 1868)				+				
Tremulicerus distinguendus (Kirschbaum, 1868)						+		
Viridicerus ustulatus (Mulsant et Rey, 1855)			+	+	+	+		
Iassus scutellaris (Fieber, 1868)			+		+			
Penthimia nigra (Goeze, 1778)			+					
Eupelix cuspidata (Fabricius, 1775)			+	+		+		
Aphrodes bicincta (Schrank, 1776)			+					
Aphrodes makarovi Zachvatkin, 1948			+					
Anoscopus albifrons mappus Guglielmino et Bückle, 2015			+					
Anoscopus serratulae (Fabricius, 1775)			+					
Stroggylocephalus agrestis (Fallén, 1806)				+			+	
Evacanthus acuminatus (Fabricius, 1794)			+					
Cicadella viridis (Linnaeus, 1758)		+	+	+	+	+		
Alebra wahlbergi (Boheman, 1845)			+					
Emelyanoviana mollicula (Boheman, 1845)	+		+	+	+	+		+

Table 4/2. Table 4. List of Auchenorrhyncha species and their collecting months.

Taxon **month**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
Dikraneura variata Hardy, 1850			+					
Wagneriala sinuata (Then, 1897)			+					
Notus italicus Wagner, 1954			+			+		
Kybos rufescens Melichar, 1896			+	+				
Kybos virgator (Ribaut, 1933)				+				
Empoasca decipiens Paoli, 1930			+	+	+	+		+
Empoasca pteridis (Dahlbom, 1850)				+	+			
Empoasca vitis (Göthe, 1875)				+				
Asymmetrasca decedens Paoli, 1932			+	+	+			
Edwardsiana diversa (Edwards, 1914)			+					
Edwardsiana prunicola (Edwards, 1914)			+	+	+	+		
Edwardsiana salicicola (Edwards, 1885)			+		+			
Linnavuoriana sexmaculata (Hardy, 1850)				+	+	+		
Ribautiana cruciata Ribaut, 1931			+					
Ribautiana debilis (Douglas, 1876)			+					
Ribautiana tenerrima (Herrich-Schäffer, 1834)			+					
Eupteryx atropunctata (Goeze, 1778)				+	+	+	+	+
Eupteryx curtisii (Flor, 1861)			+	+	+			+
Eupteryx decemnotata Rey, 1891				+				
Eupteryx melissae Curtis, 1837			+	+	+	+	+	
Eupteryx notata Curtis, 1837			+	+		+		
Eupteryx petasitidis Ferrari, 1882					+			
Eupteryx rostrata Ribaut, 1936			+	+	+	+		+
Eupteryx thoulessi Edwards, 1926			+	+		+		+
Eupteryx urticae (Fabricius, 1803)				+				
Eupteryx zelleri (Kirschbaum, 1868)			+	+				+
Zyginidia gr. *ribauti* Dworakowska, 1970	+		+	+	+	+		
Zygina discolor Horváth, 1897			+					
Zygina lunaris (Mulsant et Rey, 1855)			+	+		+		
Zygina nivea (Mulsant et Rey, 1855)				+	+	+		
Zygina cf. *ordinaria* (Ribaut, 1936)				+				
Arboridia parvula (Boheman, 1845)				+	+			
Arboridia spathulata (Ribaut, 1931)			+		+			
Fruticidia bisignata (Mulsant et Rey, 1855)						+		
Goniagnathus brevis (Herrich-Schäffer, 1835)			+		+			
Hishimonus cf. *hamatus* Kuoh, 1976						+		
Neoaliturus fenestratus (Herrich-Schäffer, 1834)			+	+	+	+		
Balclutha nicolasi (Lethierry, 1876)			+	+	+	+		+
Balclutha punctata (Fabricius, 1775)			+					
Balclutha rosea (Scott, 1876)			+			+		

Table 4/3. Table 4. List of Auchenorrhyncha species and their collecting months.

Taxon **month**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
Balclutha saltuella (Kischbaum, 1868)						+		
Macrosteles forficula (Ribaut, 1927)				+				
Macrosteles frontalis (Scott, 1875)			+	+	+	+		
Macrosteles laevis (Ribaut, 1927)				+	+	+		
Macrosteles ossiannilssoni Lindberg, 1954					+			
Macrosteles quadripunctulatus (Kirschbaum, 1868)					+			
Macrosteles sardus Ribaut, 1948				+	+	+		
Macrosteles sexnotatus (Fallén, 1806)			+	+	+			
Macrosteles viridigriseus (Edwards, 1924)			+	+	+	+		
Deltocephalus pulicaris (Fallén, 1806)			+	+	+	+		+
Maiestas schmidtgeni (Wagner, 1939)			+	+	+	+		
Chiasmus conspurcatus (Perris, 1857)			+		+	+		
Doratura paludosa Melichar, 1897				+				
Phlogotettix cyclops (Mulsant et Rey, 1855)					+			
Exitianus taeniaticeps (Kirschbaum, 1868)						+		
Anoplotettix fuscovenosus (Ferrari, 1882)			+					
Lamprotettix nitidulus (Fabricius, 1787)			+					
Allygus modestus Scott, 1876			+					
Allygidius abbreviatus (Lethierry, 1878)			+		+			
Allygidius atomarius (Fabricius, 1794)			+					
Allygidius furcatus (Ferrari, 1882)				+				
Phlepsius sp.				+		+		
Graphocraerus ventralis (Fallén, 1806)		+	+					
Cicadula lineatopunctata (Matsumura, 1908)			+		+			
Cicadula frontalis (Herrich-Schäffer, 1835)			+			+		
Cicadula placida (Horváth, 1897)			+	+	+	+	+	+
Cicadula quadrinotata (Fabricius, 1794)	+	+	+	+	+	+	+	+
Mocydia crocea (Herrich-Schäffer, 1837)	+			+				
Thamnotettix zelleri (Kirschbaum, 1868)			+					
Conosanus obsoletus (Kirschbaum, 1858)			+	+	+	+		+
Euscelis incisus (Kirschbaum, 1858)			+	+	+			
Euscelis lineolatus Brullé, 1832			+					
Artianus manderstjernii (Kirschbaum, 1868)			+	+				
Paramesus obtusifrons (Stål, 1853)				+				
Paralimnus phragmitis (Boheman, 1847)			+		+			
Metalimnus formosus (Boheman, 1845)			+	+		+	+	+
Arocephalus longiceps (Kirschbaum, 1868)	+		+	+				
Psammotettix alienus (Dahlbom, 1850)	+		+	+	+	+		+
Psammotettix confinis (Dahlbom, 1850)	+		+	+	+	+		+
Adarrus exornatus Ribaut, 1952			+		+			
Jassargus bisubulatus (Then, 1896)	+		+	+	+			
Arthaldeus striifrons (Kirschbaum, 1868)			+	+	+	+		+

Table 4/4. Table 4. List of Auchenorrhyncha species and their collecting months.

OBSERVATIONS ON SOME TAXA OF SPECIAL INTEREST

Cixius remotus Edwards, 1881 (Fig. 24)

New record for Italy.

A small population of this species was found near Madonna della Luce in June on herbaceous vegetation. The species is recorded from western Europe, UK and the Balkan Peninsula. Little is known about its biology.

Kelisia praecox Haupt, 1935 (Fig. 25)

New record for peninsular Italy.

One male was found near the Lago Ripasottile in September. In Italy, the species is recorded from Piemonte (Alma et al., 2009b). Host plants are *Carex brizoides* and other *Carex* species (Nickel, 2003; Nickel et Remane, 2002). The host plant of the population in the Lago Ripasottile area is unknown.

Kelisia punctulum (Kirschbaum, 1868) (Fig. 26)

New record for Italy.

This taxon is widely distributed in the studied area (Lago di Ventina, Lago di Piediluco, Madonna della Luce, Lago Lungo and Lago Ripasottile). It was collected in June on tall sedges. As host plant is recorded *Carex acutiformis* (Nickel, 2003). *Kelisia punctulum* is widely distributed and not rare in western, central, eastern and southeastern Europe, but apparently absent in most parts of the Mediterranean region.

Anakelisia fasciata (Kirschbaum, 1868) (Fig. 27)

New record for Italy.

The species is present in high abundance at the Lago di Ventina, but was found at the Lago Lungo, Lago Ripasottile and Madonna della Luce as well. Adults were collected from April to November. *Anakelisia* fasciata is recorded for Germany as univoltine. Hibernating takes place in the egg stage with some females hibernating as adults (Nickel, 2003). A similar condition is observed on the Lago di Ventina. Many specimens were found in autumn, with a percentage of males decreasing from October to November. In April only females were found. Only few specimens were collected in summer (end of June, mid-July), including one male. The species is monophagous on *Carex riparia* (Nickel, 2003), but possibly it uses also other tall sedges as host plants. It is widely distributed in most parts of Europe except for the northernmost regions and the Iberian Peninsula.

Chloriona smaragdula (Stål, 1853) (Figs. 28, 29)

New record for peninsular Italy.

The species was collected on the Lago Lungo in July. It is monophagous on *Phragmites australis* and is recorded from most parts of Europe except for the Iberian Peninsula.

In Italy there are records from Trentino Alto Adige (Carl, 2008), Veneto and Emilia Romagna (Servadei, 1967).

Megamelus notula (Germar, 1830) (Figs. 30, 31)

New record for Latium.

The species was found on the Lago di Ventina in September and October and is apparently sedentary in this area as all collected specimens are brachypterous. One macropterous specimen was collected also on the Lago Ripasottile, in June.

Megamelus notula lives on *Carex* spp. (Nickel, 2003). In northern Italia there are records from Trentino Alto Adige, Friuli-Venezia Giulia and Emilia (Servadei, 1967); in peninsular Italy, the species is recorded from Abruzzo (Guglielmino et al., 2005).

Megamelodes lequesnei Wagner, 19631 (Fig. 32)

New record for Italy.

Brachypterous males were collected in November both on the Lago di Ventina and the Lago Lungo. In Germany, the species is bivoltine and hibernates in the egg stage; host plants are *Juncus effusus* and *J. inflexus* (Bückle & Guglielmino, 2005), possibly also other tall *Juncus* species.

In the investigated areas, however, it lives on *Carex* spp., probably *Carex hirta*. Apparently, it hibernates in the adult stage.

The species is recorded from several European regions including Spain, the British Islands and the Balkan region.

Delphacodes mulsanti (Fieber, 1866) (Fig. 33)

New record for Latium.

The taxon is widely distributed in the studied areas (Madonna della Luce, Lago Lungo, Lago Ripasottile and Montisola). The specimens were collected in June, September, October and November, possibly on *Eleocharis* sp.

Fieber (1866) described this taxon from southern France. As usual in those times, he did not consider the aedeagus morphology. Subsequent description of further *Delphacodes* taxa based principally on the aedeagus shape, raised the question of their relationship or possible identity with *D. mulsanti*. Until 1983, four further taxa of this group had been described: (1) *D. ornatipennis* (Haupt, 1927), based on one female from Palestina, (2) *D. audrasi* Ribaut, 1954, from eastern France, (3) *D. fascia* (Lindberg, 1960), from Portugal, and (4) *D. linnavuorii* (Le Quesne, 1960), described from central Italy (Toscana) on a specimen figured by Linnavuori (1957) as *D. mulsanti*. Asche & Remane (1983) discussed this problem in a long article in which they described an additional species, (5) *D. nastasi*, from Greece. Out of these taxa, four are recorded by D'Urso (1995) from Italy: *D. mulsanti*, *D. linnavuorii*, *D. audrasi* and *D. nastasi*.

In the meantime, Asche (pers. com.) had the opportunity to study the type of *D. audrasi* and material on which Fieber's original description of *Delphax mulsanti* was based. In addition, he studied a rich *Delphacodes* material from Irak, collected by R. Linnavuori, which displays a surprisingly high variability in the aedeagus morphology. All the species of the *mulsanti* group mentioned above are represented in the variation spectre of these populations. Our own material from Sardinia and peninsular Italy comprises at least the aedeagus morphology of *D. fascia*, *D. nastasi* and transitional forms. A quite different aedeagus shape is represented by the specimen figured by Linnavuori (1957) from Toscana as *D. mulsanti*, and later described by Le Quesne (1960) as *D. linnavuorii*. Nevertheless, the aedeagus shape of this specimen as well is within the spectre of variability of the material from Irak observed by Asche.

These observations suggest clearly that the five species mentioned above are conspecific with *D. mulsanti*. We propose the following synonymies:

Delphax mulsanti, Fieber, 1866 = *Megamelus ornatipennis* Haupt, 1927 = *Delphacodes audrasi* Ribaut, 1954 = *Calligypona fascia* Lindberg, 1960 = *Megamelodes linnavuorii* Le Quesne, 1960 = *Delphacodes nastasi* Asche et Remane, 1983 (syn. nov.) (see also Haupt, 1927; Lindberg, 1960; Ribaut, 1954).

Struebingianella lugubrina (Boheman, 1847) (Figs. 34, 35)

New record for peninsular Italy.

A very rich population of this species was found on the Lago di Ventina, in April and September, on *Glyceria maxima*. As host plant is recorded also *G. fluitans* (Nickel, 2003). The species hibernates in the nymph stage, and has two generations (Nickel, 2003).

It was recorded in Italy only from Friuli-Venezia Giulia (Servadei, 1967).

Interestingly, a high number (about 30%) of the collected males have a mirror image symmetric aedeagus in respect of the aedeagus type generally observed in the populations from central Europe (as figured e.g. in Ossiannilsson, 1978, Figs. 510–512).

Ribautodelphax albostriata (Fieber, 1866) (Fig. 36)

New record for Latium.

Brachypterous and macropterous adults were found on the Lago Lungo in July and September. The species is monophagous on *Poa pratensis*. In Italy there are records from Valle d'Aosta (Alma et al., 2009a), Trentino Alto Adige (Remane & Hellrigl, 1996), Friuli Venezia Giulia, Liguria (Guglielmino & Bückle, 2007), Emilia Romagna (Guglielmino & Bückle, 2008), Toscana, Abruzzo (Guglielmino et al., 2005). The species hibernates in the nymph stage and has two generations (Nickel, 2003). It is widely distributed and rather common in central Italy.

Macropsis prasina (Boheman, 1852) (Fig. 37)

The species was found near Madonna della Luce in June.

This taxon is mentioned in the Servadei catalogue apparently as *M. virescens* (Fabricius, 1794) and recorded for Piemonte, Liguria and Trentino-Alto Adige. Generally, there was much confusion in the past about the taxonomy of this genus, and until today *Macropsis* is one of the most complicated Cicadellidae genera in Europe. Therefore, old records are unclear and may be interpreted in different ways. Species discrimination, above all among the green species, is sometimes impossible without the indication of the host plant; as material from old collections is normally devoid of such information its identification is particularly difficult. We found no specimens in the Servadei collection that can be attributed surely to *M. prasina* (most of the specimens belonging to the label "*prasina*" display the ovipositor features of *M. marginata*).

Notus italicus Wagner, 1954 (Fig. 38)

New record for Latium.

The species was found only on the Lago di Ventina, and is apparently restricted there to *Carex paniculata* as host plant.

The species is described from Trentino-Alto Adige and Veneto, and there are records from several other regions in northern Italy (Servadei, 1967). On the Apennine Peninsula it is recorded from Abruzzo (Guglielmino et al., 2005) and Calabria (Servadei, 1967).

Kybos virgator (Ribaut, 1933) (Fig. 39)

During our research one male was collected on *Salix alba* near the Lago Ripasottile.

In Italy there are records only from Veneto and Sardinia (Servadei, 1967). The species feeds primarily on *S. alba* and *S. fragilis* (Nickel, 2003).

In 2011, a new *Kybos* species, *K. albitalicus* Guglielmino, Poggi, Bückle, 2011 was described (Guglielmino et al., 2011). This taxon feeds on *S. alba* as well (and on *S. eleagnos*), is quite common in central Italy and is distinguishable from *K. virgator* mainly by the morphology of its tymbal organ. Therefore, records before 2011 are to be checked; they may refer possibly to *K. albitalicus*. The male collected in the Lago Ripasottile area displays long, well developed apodemes of the second abdominal sternum; thus, it belongs clearly to *K. virgator*.

Zygina lunaris (Mulsant et Rey, 1855) (Fig. 40)

New record for Latium.

Adults were found on the Lago Lungo, Lago Ripasottile and Lago di Ventina, on *Salix alba* in July and September. The species lives prevalently on narrow-leaved *Salix* species (*S. alba*, *S. fragilis*, *S. purpurea*, etc.) (Nickel, 2003). In Italy there are records from Piemonte (Alma et al., 2009b) and Toscana (Mazzoni et al., 2001).

Zygina cf. ***ordinaria*** (Ribaut, 1936) (Fig. 41)

New record for Latium.

Adults were collected on the Lago Lungo and Lago Ripasottile, on *Salix alba*, in July. The species lives on narrow-leaved *Salix* species (*S. alba*, *S. viminalis*, *S. fragilis*, *S. purpurea*, etc.) (Nickel, 2003).

This taxon is generically recorded from Italy by Vidano and Arzone (1987); recently, it was collected in Trentino Alto Adige (Carl, 2008), Emilia Romagna (Guglielmino & Bückle, 2008) and Toscana (Mazzoni, 2005).

Hishimonus cf. ***hamatus*** Kuoh, 1976 (Fig. 42)

New record for peninsular Italy.

One specimen was collected in September near Madonna della Luce and the Lago Ripasottile, respectively.

This species was recently introduced in Europe and is present in Slovenia (Seljak, 2013) and northern Italy (Lombardy: Francesco Poggi, unpublished data).

Cicadula frontalis (Herrich-Schäffer, 1835) (Fig. 43)

New record for Latium.

The species was found in June and September only in a restricted area near Madonna della Luce, on *Carex acutiformis* and/or *C. riparia*.

The species is widely distributed in most parts of Europe. In Italy there are records from Emilia and Calabria (Servadei, 1967). In the Servadei collection of the museum of Verona there are no specimens of this taxon from Italy.

Cicadula placida (Horváth, 1897) (Fig. 44)

New record for Latium.

The taxon is widely distributed and common in the studied area (Lago di Ventina, Lago di Piediluco, Madonna della Luce, Lago Lungo, Lago Ripasottile and Montisola). Adults were collected in June, July, October and November. The species feeds on *Phalaris arundinacea*, *Glyceria maxima*, and possibly also on other tall Poaceae species. Specimens collected in June were light yellow-green, specimens collected in November brown.

The species is recorded in Italy from Piemonte (Servadei, 1967) and Toscana (Mazzoni, 2005).

Metalimnus formosus (Boheman, 1845) (Fig. 45)

New record for peninsular Italy.

Specimens of this taxon were collected on the Lago di Ventina from June to November. The species feeds on *Carex* spp. In Germany *C. acuta* and *C. elata* are recorded as host plants (Nickel, 2003). In the Lago di Ventina area, the species feeds on *Carex riparia*, *C. paniculata* and possibly further *Carex* species.

In Italy it is recorded from Piemonte, Trentino Alto Adige and Friuli Venezia Giulia (Servadei, 1967).

CONCLUSIONS

The number of vascular plants (267) and Auchenorrhyncha species (162) emphasizes the high biodiversity of the Lacus Velinus area. However, not only the quantity of species but also the particular interest of some of them is an important result. Among the vascular plants are to be recorded in this context *Butomus umbellatus*, *Carex acutiformis*, *C. elata*, *C. pseudocyperus*, *C. paniculata*, *Cladium mariscus*, *Epipactis palustris*, *Frangula alnus*, *Glyceria maxima*, *Hydrocharis morsus-ranae*, *Nuphar lutea*, *Oenanthe aquatica*, *Orchis incarnata*, *Ranunculus lingua*, *Rorippa amphibia*, *Rumex hydrolapathum*, *Scutellaria galericulata* and *Viburnum opulus*, all included in the Regional Red Lists of Italian Plants of Umbria and Latium.

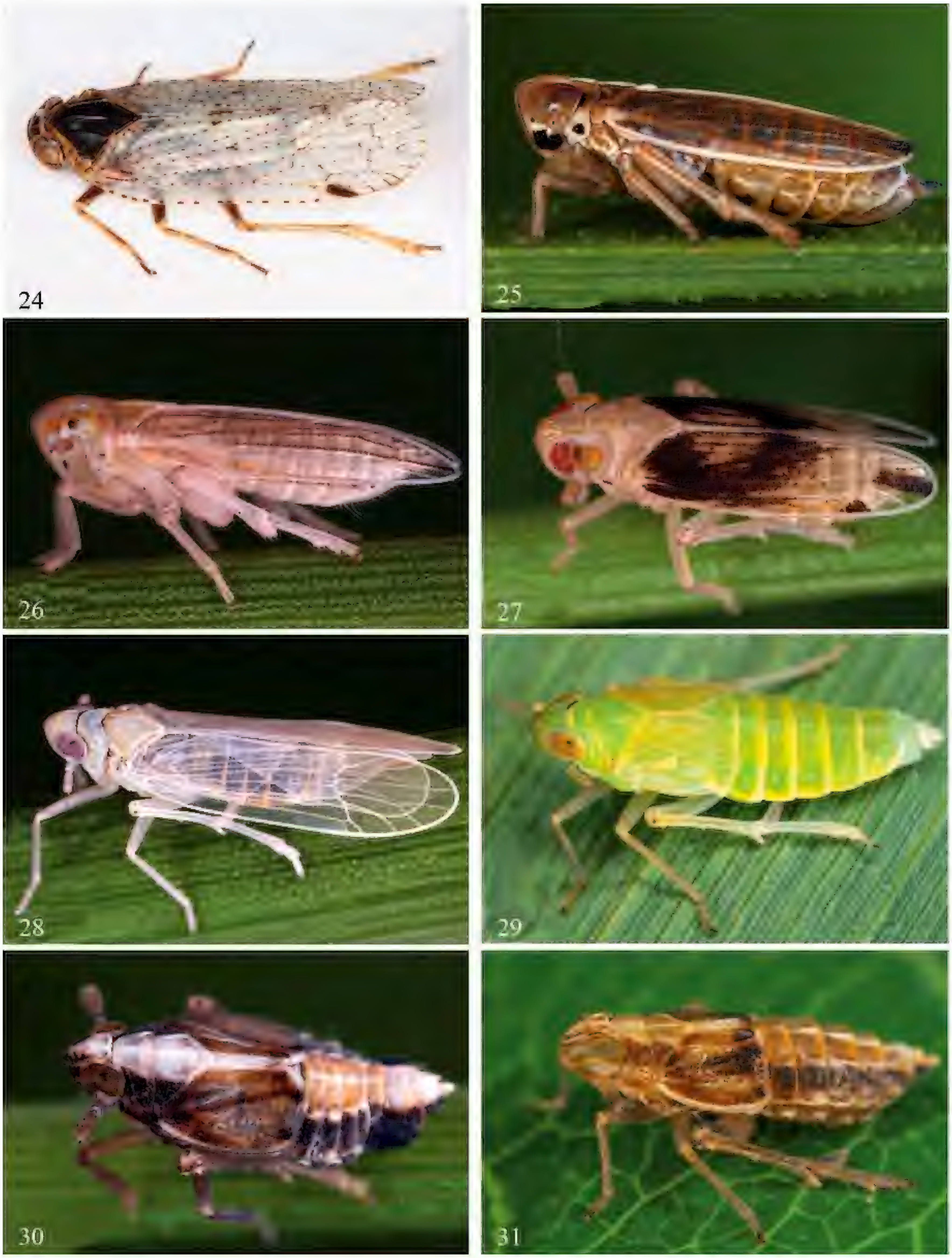
Among the Auchenorrhyncha we mention four species (*Cixius remotus*, *Kelisia punctulum*, *Anakelisia fasciata* and *Megamelodes lequesnei*) as new for Italy and five (*Kelisia praecox*, *Struebingianella lugubrina*, *Chloriona smaragdula*, *Hishimonus* cf. *hamatus* and *Metalimnus formosus*) as new for the Apennine Peninsula ("S" in the checklist of the Italian fauna). Besides, most of the collection sites even seen in isolation present impressively rich Auchenorrhyncha communities. 83 species were found at the Lago di Ventina, 89 at the Lago di Piediluco, 65 near Madonna della Luce, 61 at the Lago Lungo, 76 at the Lago Ripasottile, 47 near Montisola and 14 on the river Velino. The different numbers are in part due to a different sampling intensity and a different spatial, ecological and temporal extension of the collecting sites and periods. However, the low species number in the localities near Montisola and on the river Velino in respect of the other sites is in part correlated with a lower diversity of plants in those distinctly disturbed habitats.

In addition to the high number of taxa occurring in the investigated area, a very important result consists in the high number of 60 taxa that are strictly correlated with moist habitats. Most of the species recorded for the first time in Italy or peninsular Italy belong to this group.

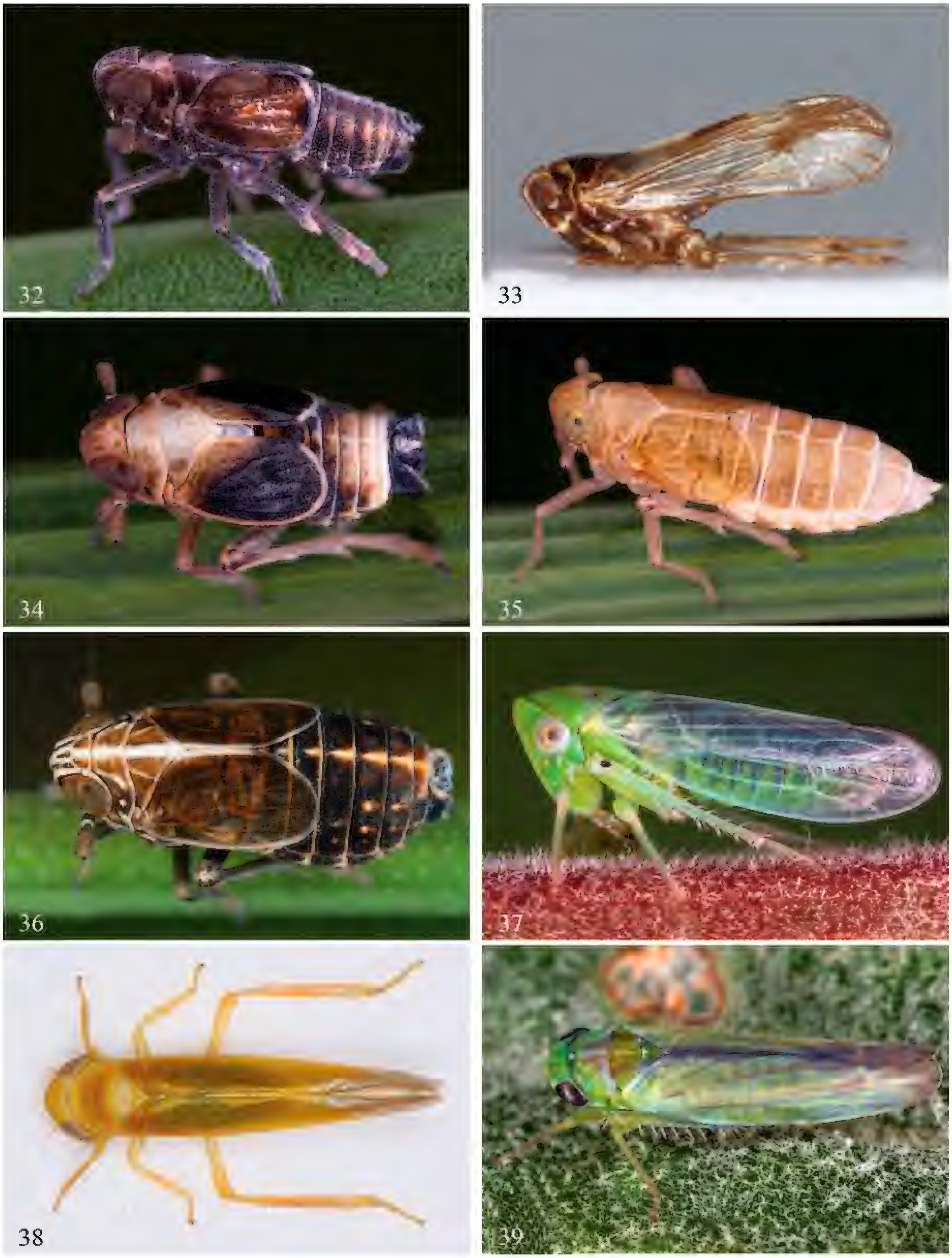
The present research emphasizes also the lack of data concerning the Auchenorrhyncha species in Latium and above all in Umbria. While 18 taxa of Auchenorrhyncha are new records for Latium (from six sampling localities), no less than 44 are new for Umbria (in spite of this region being represented by only two sampling localities). However, a subdivision of our results in data from Latium and from Umbria makes little sense. The investigated area is a single ecological and geological unit, despite of its belonging to two different administrative entities. The site of the Lago di Piediluco (in Umbria), for example, is only about 250 m distant from the border of Latium and about 1km distant from the site "Madonna della Luce" (in Latium).

Nowadays humid habitats in central Italy are generally rare. Often they have been destroyed or at least severely compromised already in Roman times. Therefore, an area with such high number of hygrophilous plants and Auchenorrhyncha taxa as the "Lacus Velinus" region deserves particularly high attention and protection. This not only in view of the Flora and the Auchenorrhyncha fauna (and the Avifauna), but also in regard of other groups of animals which are unexplored until now, and may be expected to be represented by many further rare and interesting taxa. The uncontrolled diffusion of alien and invasive plant species may become a serious risk for the conservation of the biodiversity of this area, the remarkable naturalistic interest of which this research has confirmed.

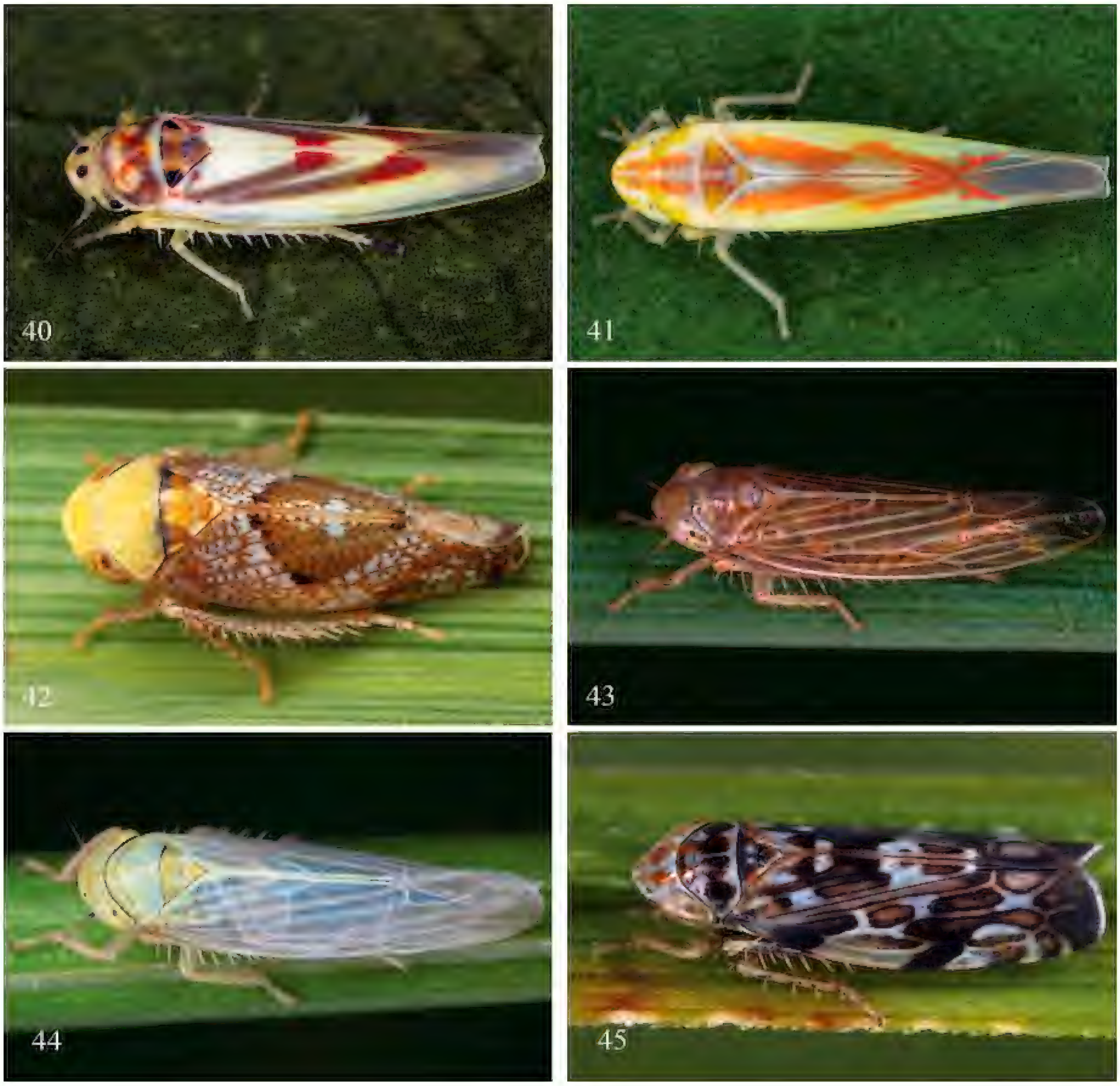
Even if the studied areas furnished very important results, we are far from an approximately complete knowledge on their Auchenorrhyncha fauna. Additional investigations should include more localities, biotopes and collecting seasons.



Figures 24–31. Auchenorrhyncha from study areas. Figure 24. *Cixius remotus*. Figure 25. *Kelisia praecox*. Figure 26. *Kelisia punctulum*. Figure 27. *Anakelisia fasciata*. Figure 28. *Chloriona smaragdula*, macropterous male. Figure 29. *Chloriona smaragdula*, brachypterous female. Figure 30. *Megamelus notula*, male. Figure 31. *Megamelus notula*, female. Figures 25–31: Photos Gernot Kunz.



Figures 32–39. Auchenorrhyncha from study areas. Figure 32. *Megamelodes lequesnei*. Figure 33. *Delphacodes mulsanti*. Figure 34. *Struebingianella lugubrina*, male. Figure 35. *Struebingianella lugubrina*, female. Figure 36. *Ribautodelphax albostriata*. Figure 37. *Macropsis prasina*. Figure 38. *Notus italicus*. Figure 39. *Kybos virgator*. Figures 32, 34–37, 39: Photos Gernot Kunz; Figures 33, 38: Photos Massimo Vollaro.



Figures 40–45. Auchenorrhyncha from study areas. Figure 40. *Zygina lunaris*. Figure 41. *Zygina ordinaria*. Figure 42. *Hishimonus* cf. *hamatus*. Figure 43. *Cicadula frontalis*. Figure 44. *Cicadula placida*. Figure 45. *Metalimnus formosus*. Photos Gernot Kunz.

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MONOGRAPH

Pselaphinae (Coleoptera Staphylinidae) from Sicily and Calabria (Italy). Results from a short entomological expedition in April, 2015

Giorgio Sabella[1*], Rostislav Bekchiev[2] & Rumyana Kostova[3]

[1]Department of Biological, Geological and Environmental Sciences, Animal Biology Section, via Androne 81, 95124 Catania, Italy; e-mail: sabellag@unict.it
[2]National Museum of Natural History, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria; e-mail: bekchiev@nmnhs.com
[3]Department of Zoology and Anthropology, Faculty of Biology, Sofia University, 8 Dragan Tsankov Bvld., Bulgaria; e-mail: rkostova@biofac.uni-sofia.bg
*Corresponding author

ABSTRACT The study presents the results from an entomological expedition in Southern Italy. Two rare species, *Batrisodes adnexus* (C. Hampe, 1863) and *Chennium siculum* Fiori, 1914, were collected in Sicily and three species, *Panaphantus atomus* Kiesenwetter, 1858, *Bibloplectus pusillus* (Denny, 1825), and *Bibloplectus delhermi* (Guillebeau, 1888), are recorded for the first time from Calabria.

KEY WORDS Italy; Pselaphinae; faunistics; taxonomy; new record.

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INTRODUCTION

A short entomological expedition was conducted in April 2015 as a result of the collaboration between Catania University (Italy), National Museum of Natural History of Sofia (NMNHS) and Sofia University (Bulgaria). While the region of Sicily is relatively well studied about Pselaphinae fauna (Sabella, 1998), in the contrary the coastal region of Calabria is still poorly investigated. The aim of this expedition was to collect material from specific habitats for Southern Italy with scarce information about the Pselaphinae species composition.

MATERIAL AND METHODS

The material was collected from 01 to 08.IV.2015 in the region of Sicily and from 09 to 12.IV.2015 in the region of Calabria. The main visited habitats were mountain and plane forests so as wet zones in Sicily and mainly coastal dunes in Calabria (Figs. 1–5).

The following collection methods were used: 1. Sifting with litter reducer (mesh diameter 6x6 mm). The beetles were sorted up manually directly from the sifted leaf litter or rotten wood or were extracted using Winkler/Moczarski selectors from 2.5–3 kg soil samples; 2. Light trap with a 160W MBTF lamp and a F8T5 - 365 nm black light tube; 3. Sweeping on the vegetation with an entomological net and with a one-hand blower (Partner GBV 325). 4. Collection at sight under stones and among the roots of herbaceous vegetation.

Determination of the species was made by dissections using standard techniques: genitalia and small parts were mounted in Euparal on acetate labels which were pinned with the specimens.

The material used for this study is deposited in the National Museum of Natural History, Sofia, Bulgaria (NMNHS) and in the Department of Biological, Geological and Environmental of Catania University (DBUC).

The general distribution of the species is given according to Poggi & Sabella (2005) and Schülke & Smetana (2015). In references all authors of the mentioned species are listed. The map was produced with SimpleMappr (Shorthouse, 2010).

RESULTS

In total, 186 specimens belonging to 23 Pselaphinae species were collected during the study (12 species from Sicily and 12 species from Calabria), with one species, *Bryaxis italicus* (Baudi di Selve, 1870), common for both regions.

List of the identified Pselaphinae species from the studied regions

SICILY

Trimium zoufali Krauss, 1900

EXAMINED MATERIAL. NEBRODI - San Fratello (Messina), N37.94540 E14.62729, 05.IV.2015, sifting litter, 1 male and 1 female (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Endemic of mainland Italy (from Emilia to Calabria) and Sicily. Widespread in Sicily. Sylvicolous species that lives in litter and rotten wood.

Batrisodes adnexus (C. Hampe, 1863)

EXAMINED MATERIAL. NEBRODI. San Teodoro (Cesarò, Messina), N37.87024 E14.67808, 05.IV.2015, 1 male (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

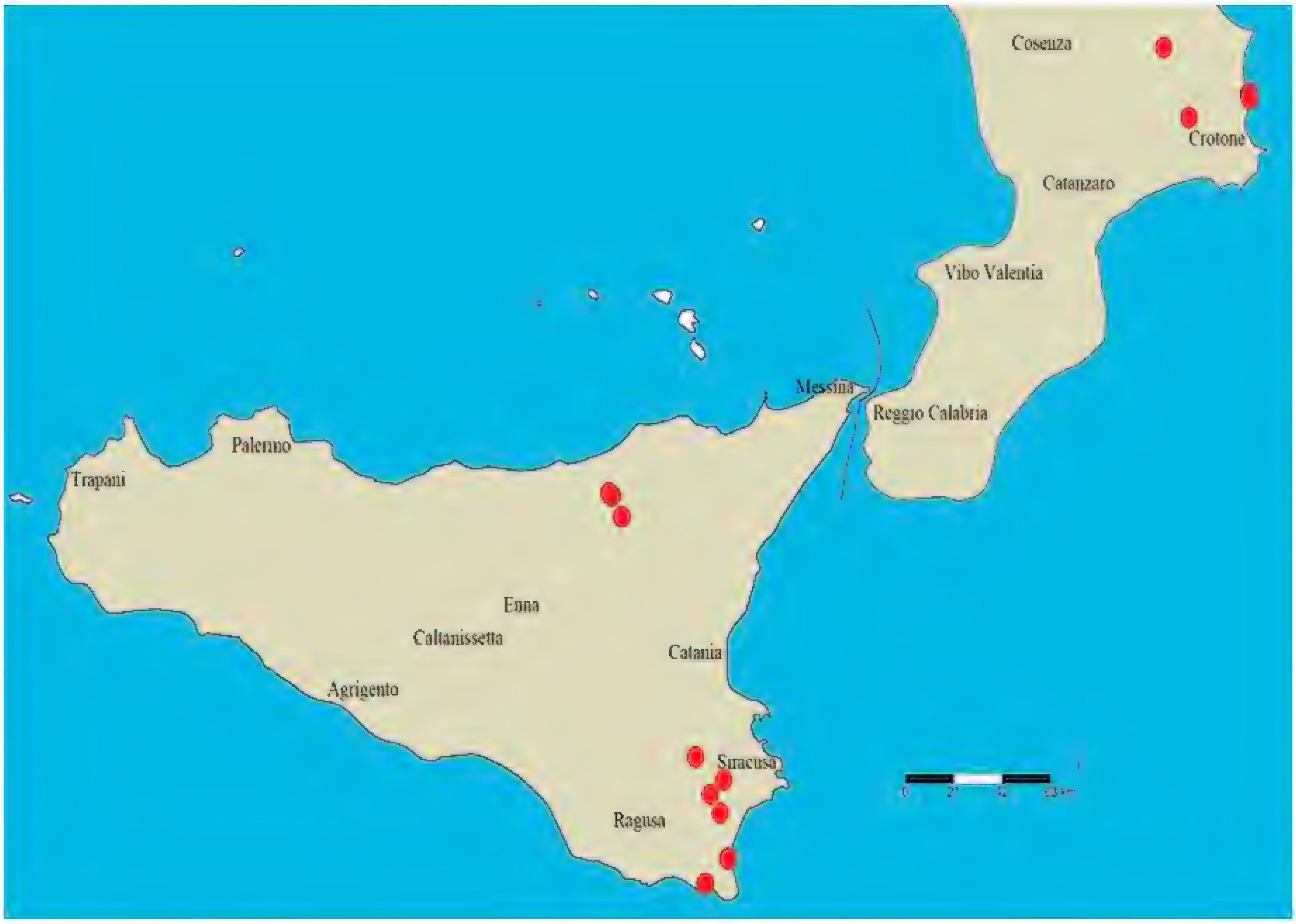

Figure 1. Map of the main points of the studied area in South Italy.

Remarks. Widespread in Europe. Reported for mainland Italy and Sicily. Not very common in Sicily where is known only to the northern districts (Peloritani, Etna, Nebrodi, Madonie and Sicani). In literature it is mentioned as myrmecophilous species (generally hosted in nests of *Lasius brunneus* (Latreille, 1798), but it was collected also with car net, entomological net and sifting of rotten wood.

Bryaxis siculus Fiori, 1913

Examined material. IBLEI. Villa Vela (Noto, Siracusa), N36.98767 E15.02672, sifting litter, 04.IV.2015, 3 males and 1 female (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS). IBLEI. Cassaro (Noto, Siracusa), N37.10304 E14.96445, 06.IV.2015, sifting litter, 2 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

Remarks. Endemic to Sicily (Iblei, Madonie and Sicani districts). Sylvicolous species living in litter and sometimes also under big stones in forest.

Bryaxis italicus (Baudi di Selve, 1870)

Examined material. NEBRODI. San Fratello (Messina), N37.94540 E14.62729, 05.IV.2015, sifting litter, 3 males (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

Remarks. Reported from southern France (Var, Alpes Maritimes), Switzerland (Ticino), mainland Italy, Elba and Giglio islands, and Sicily. In Sicily it is known only to the northeastern regions (Peloritani, Etna, Nebrodi and Erei districts). Very common in sifting of vegetal debris, litter and potting soil.

Tychus opuntiae (Schmidt-Goebel, 1836)

Examined material. IBLEI. Villa Vela (Noto, Siracusa), N36.98767 E15.02672, 04.IV.2015, sifting litter, 1 male (R. Bekchiev, G. Sabella, R.

Figures 2–5. Typical habitats: Vendicari, Sicilia (Fig. 2); Nebrodi, San Fratello, Sicilia (Fig. 3); Marina di Strongoli, Calabria (Fig. 4); Santa Severina, Calabria (Fig. 5).

Kostova) (NMNHS). NEBRODI. San Teodoro (Cesarò, Messina), N37.87024 E14.67808, 05.IV.2015, under stones, 2 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Endemic of Sicily and Malta. Widespread in Sicily. Very common under stones in wet and clay meadows, in sifting of litter and vegetal debris, among the roots of plants in swampy areas; collected also by net car, window traps and entomological net at sunset on herbaceous vegetation in wet meadows.

Brachygluta aubei (Tournier, 1868)

EXAMINED MATERIAL. IBLEI. Granelli (Pachino, Siracusa), N36.70844 E15.00519, 03.04.2015, sifting and sweeping, 11 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS). IBLEI. Vendicari (Noto, Siracusa), N36.78723 E15.09456, 01.IV.2015, sifting and sweeping, 3 males (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Known of coasts of Portugal and Spain, atlantic coast of France, Sardinia and circumsardinians islands, Sicily, Malta, islands of Favignana, Pantelleria and Galita, and Maghreb (Tunisia, Algeria and Morocco). Widespread in all coasts of Sicily and also in the central regions along riversides of salty streams or rivers. Halophilous species, common in coastal marshes and also along the riversides of salty rivers among the roots of plants. It was collected also with net car and entomological net on the riparian vegetation.

Brachyhluta dentiventris (Saulcy, 1876)

EXAMINED MATERIAL. IBLEI. Granelli (Pachino, Siracusa), N36.70844 E15.00519, 03.IV.2015, sweeping, 1 male (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Widespread in the western Mediterranean basin, mentioned of Portugal, Spain, southern France, Corsica, islands of Elba and Giglio, Sardinia and circumsardinians islands, Italy mainland (Liguria, Tuscany, Basilicata and Apulia) Sicily, Malta, islands of Pantelleria and Galita, and Maghreb (Tunisia, Algeria and Morocco). Not very common but widespread in Sicily. It is found under stones in wet and clay meadows and among the roots of plants in swampy areas.

Brachygluta ragusae (Saulcy, 1876)

EXAMINED MATERIAL. NEBRODI. San Fratello (Messina), N37.94540 E14.62729, 05.IV.2015, under stones, 10 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS). San Teodoro (Cesarò, Messina), N37.87024 E14.67808, 05.IV.2015, under stones, 3 males and 2 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Reported of mainland Italy (from Tuscany to Calabria), Sicily and Pantelleria island and also mentioned by Gridelli (1950: 22) of Dalmatia. Very common and widespread in Sicily. Gen-erally under stones in wet and clay meadows, sometimes sifting vegetal debris along the riversides of streams.

Trissemus antennatus antennatus (Aubé, 1833)

EXAMINED MATERIAL. IBLEI. Villa Vela (Noto, Siracusa), N36.98767 E15.02672, 04.IV.2015, sifting litter, 1 male and 4 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Subspecies reported of Germany, Switzerland, Austria, France, Corsica, mainland Italy, Elba island, Sardinia and Sicily. Very common and widespread in Sicily. It lives in many habitat: marshes, swampy areas, riversides of streams, under stones in wet meadows, in litter and vegetal debris and it is also cacthed by net car, window traps and entomological net.

Pselaphogenius peloritanus (Holdhaus, 1910)

EXAMINED MATERIAL. IBLEI. Canicattini Bagni (Siracusa), N37.03649 E15.07537, 06.IV.2015, sifting litter, 1 female (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS). NEBRODI. San Fratello (Messina), N37.94540 E14.62729, 05.IV.2015, sifting litter, 2 males and 2 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS). San Fratello (Messina), N37.93678 E14.63943, 05.IV.2015, sifting litter, 2 males and 1 female (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Endemic of Sicily, where it is widespread in the forestal habitat. Generally in sifting of litter, sometimes under big stones in forest and in sifting of vegetal debris.

Chennium siculum Fiori, 1914 (Fig. 6)

Examined material. NEBRODI. San Teodoro (Cesarò, Messina), N37.87024 E14.67808, 05.IV.2015, entomological net, 1 male (I. Gjonov) (NMNHS).

Remarks. Endemic of northern Sicily (Sicani and Nebrodi districts). Myrmecophilous species, generally hosted in nests of *Tetramorium caespitum* (Linnaeus, 1758) and *Lasius brunneus* (Latreille, 1798), but also collected at sunset by entomological net on herbaceous vegetation in wet meadows.

Ctenistes kiesenwetteri Saulcy, 1874

Examined material. NEBRODI. San Fratello (Messina), N37.94540 E14.62729, 05.IV.2015, under stones, 11 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

Remarks. Reported of Algeria, Tunisia and Sicily. Very common and widespread in Sicily. Generally collected under stones in wet and clay meadows but also among the roots of plants in swampy areas, rarely in sifting of litter and vegetal debris.

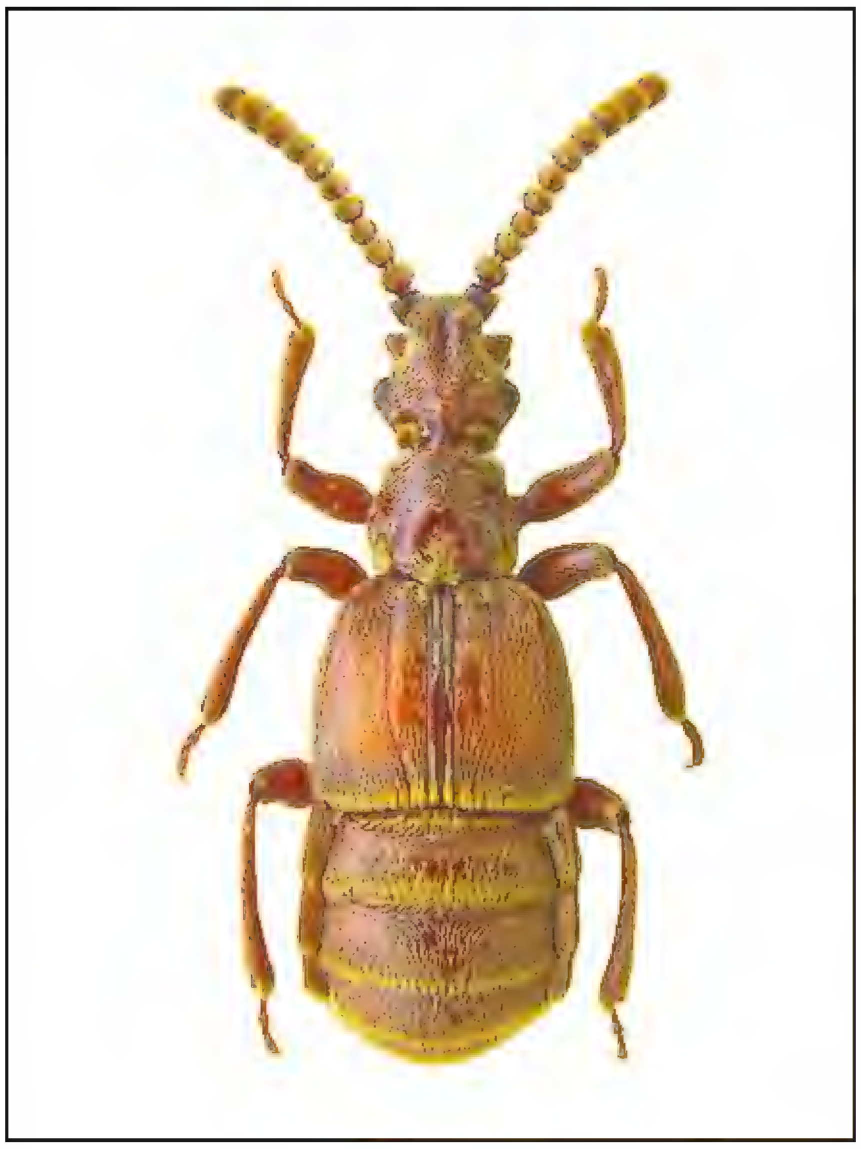

Figure 6. Habitus of *Chennium siculum* Fiori, 1914.

CALABRIA

Panaphantus atomus Kiesenwetter, 1858

Examined material. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sifting litter, 2 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

Remarks. Localised but widespread in Mediterranean basin: Maghreb (Tunisia, Algeria and Morocco), southern France, Corsica, mainland Italy (Veneto, Liguria, Emilia, Tuscany, Umbria and Latium), Sardinia, Sicily, Croatia, Bosnia-Herzegovina, Greece, islands of Corfu and Crete, Georgia, Azerbaijan, Israel and northwestern Iran. New record from Calabria. It lives in marshes and swampy areas among the roots of plants or under vegetal debris.

Euplectus bonvouloiri narentinus Reitter, 1882

Examined material. CROTONESE. Verzino (Crotone), N39.35211 E16.80282, 10.IV.2015, sifting, 1 male and 1 female (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS); same data, 1 female (R. Bekchiev, G. Sabella, R. Kostova) (DBUC).

Remarks. This subspecies is widespread in central and southern Europe and it is mentioned for all mainland Italy. It lives in litter and rotten wood.

Euplectus verticalis Reitter, 1884

Examined material. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sweeping and sifting, 2 males (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

Remarks. Distributed in the regions of south-eastern of Mediterranean basin (Slovenia, Macedonia, Italy, Greece, islands of Corfu, Zante, Crete and Rodi, Israel and Turkey). In Italy is reported for Tuscany, Latium, Calabria and Sicily. Generally it is collected by sifting litter, vegetal debris and rotten wood, alongside the riversides of streams and rivers and in swampy areas.

Bibloplectus delhermi Guillebeau, 1888

EXAMINED MATERIAL. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sifting litter, 1 male and 1 female (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Reported of Great Britain, Germany, Switzerland, southern Austria, France, mainland Italy (Veneto, Emilia, Tuscany, Latium and Basilicata), Giglio island, Sicily, Greece, Slovakia, Hungary and Turkey. New record from Calabria. It lives in marshes and swampy areas among the roots of plants or under vegetal debris.

Bibloplectus pusillus (Denny, 1825)

EXAMINED MATERIAL. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09-10.IV.2015, sweeping and sifting, 10 males and 14 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Widespread in Europe and mentioned also from Turkey. In Italy is mentioned of the mainland (Piemonte, Lombardia, Friuli Venezia-Giulia, Veneto, Emilia, Liguria, Tuscany, Latium, Umbria and Basilicata), Sardinia and Sicily. New record from Calabria. Same habitat of the previous species.

Trimium paganettii Reitter, 1906

EXAMINED MATERIAL. CROTONESE. Santa Severina (Crotone), N39.13331 E16.90204, 10.IV.2015, sifting litter, 2 males and 2 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS), same data, 1 male and 2 females (R. Bekchiev, G. Sabella, R. Kostova) (DBUC).

REMARKS. Endemic of southern Italy, until now known from Campania, Apulia, Basilicata, Calabria and Sicily. Sylvicolous species that lives in litter and rotten wood.

Tychobythinus glabratus (Rye, 1870)

EXAMINED MATERIAL. CROTONESE. Santa Severina (Crotone), N39.13331 E16.90204, 10.IV.2015, sifting litter, 2 males and 2 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS); same data, 2 females (R. Bekchiev, G. Sabella, R. Kostova) (DBUC).

REMARKS. Reported of southern England, Germany, Belgium, France, Switzerland, Italy, Slovenia, and Croatia (Dalmatia). Known of mainland Italy, islands of Elba, Palmarola, Zannone and San Domino, and Sicily, where it seems confined only in the Peloritani district. In Italy the species was collected under very big stones or sifting litter and vegetal debris, while in the northermost regions of its distribution area it is mentioned as myrmecophilous species.

Bryaxis italicus (Baudi di Selve, 1870)

EXAMINED MATERIAL. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sifting litter, 14 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. For information on this species, refer to the discussion made earlier.

Tychus pullus Kiesenwetter, 1858

EXAMINED MATERIAL. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sifting litter, 1 male and 4 females (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Species distributed in eastern Mediterranean basin, known for Italy, Slovenia, Croazia, Serbia, Montenegro, Bosnia-Herzegowina, Albania, Macedonia, Bulgaria, Greece, Slovakia, Hungary and Turkey. In Italy is reported for Veneto, Emilia, Tuscany, Umbria, Tuscany, Apulia, Basilicata and Calabria. It is found in marshes and swampy areas among the roots of plants, under vegetal debris and under stones.

Rybaxis longicornis (Leach, 1817)

EXAMINED MATERIAL. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sifting and swipping, 21 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Species widespread in all Europe (including England and Ireland), Thyrrhenians islands, North Africa, Minor Asia and Central Asia. It is present throughout Italy mainland, Sardinia and circumsardinians islands and Sicily. It lives in marshes, swampy areas, riversides of streams and rivers and wet meadows, among the roots of plants, under vegetal debris and under stones. It seems to prefer salty soils.

Pselaphus parvus Karaman, 1940

EXAMINED MATERIAL. CROTONESE. Mouth of Neto river (Marina di Strongoli, Crotone), N39.19115 E17.13858, 09–10.IV.2015, sifting and swipping 22 ex. (R. Bekchiev, G. Sabella, R. Kostova) (NMNHS).

REMARKS. Known of Austria (Eastern Tirol); Switzerland, France (Maritime Alps), Corse, Italy, Slovenia, and Croatia (Istria). In Italy only in the mainland. It is found in marshes, swampy areas, riversides of streams and rivers, among the roots of plants or under vegetal debris.

Pselaphogenius sp. gr. ***fiorii***

EXAMINED MATERIAL. CROTONESE. Verzino (Crotone), N39.35211 E16.80282, 10.IV.2015, sifting litter, 1 male and 1 female (R. Bekchiev, G. Sabella, R. Kostova) (DBUC).

REMARKS. The specimens are still being studied. Based on the exoskeletal morphology and aedeagal features character, they are attributable with certainty to the *Pselaphogenius fiorii* group (Sabella, 1992) and are closely related to *Pselaphogenius aspromontanus* (Reitter, 1910).

CONCLUSIONS

A first result of this entomological expedition in Sicily and Calabria, two rare Pselaphinae species, *Chennium siculum* and *Batrisodes adnexus*, were collected from Sicily, while three species, *Panaphantus atomus, Bibloplectus pusillus,* and *Bibloplectus delhermi*, are recorded for the first time from Calabria.

ACKNOWLEDGMENTS

We wish to thank prof. A. Petralia, Ente Fauna Siciliana (Noto, Italy) and F. La Manna (Crotone, Italy) for their kind assistance during the expedition.

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Biodiversity Journal, 2017, 8 (1): 193–204 **MONOGRAPH**

Taxonomical notes on some poorly known mollusca species from the Strait of Messina (Italy)

Alberto Villari[1] & Danilo Scuderi[2*]

[1]Via Villa Contino 30, 98124 Messina, Italy; e-mail: villaria@tiscali.it
[2]Via Mauro de Mauro 15b, 95032 Belpasso, Catania, Italy; e-mail: danscu@tin.it
*Corresponding author

ABSTRACT The finding of some species of Mollusca interesting either for their distributional pattern, taxonomy or simply for the new iconography here presented are reported. Some species represent the first finding in Italian waters or the first record of living specimens. As a consequence, they furnished interesting data on habitat preferences and the external morphology of the living animal, which are hereafter reported. The taxonomy of some problematic taxa is here discussed, reporting new name combinations, while for others the question remains open. Discussions, comparisons and a new iconography are here reported and discussed.

KEY WORDS Mollusca; poorly known species; Messina Strait; Mediterranean Sea.

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INTRODUCTION

Notwithstanding a lot of inedited papers on the biodiversity of the Messina’s Strait were produced in the past, from the XVIII century to recent time, numerous new notices are added every year. This richness of interesting findings is due to the particular series of coincidences, from the peculiar currents to the very characteristics geo-morphology of the site, which play a fundamental role for a high hydrodynamism, already well known since Omer’s time, and its influence on maintaining a wide range of environmental conditions deeply connected to the large variety of ecological niches. From the deep bottoms to the lower water biocoenosis, the Messina's Strait had ever offered to researches a complete series of data in every possible field of marine biology, from Algae to jellyfish, to ichthyology and malacology. As an example, beyond data of his life as a researcher, the recent biography of A. Cocco includes even interesting romantic notices of the scientific activity in Europe (Ammendolia et al., 2014) and the Messina Strait in particular, as could be inferred by its definition as “the Paradise of Zoologist” done by August David Krohn (Battaglia et al., 2012).

In the XIX century numerous contributions regarded the Messina’s Strait malacology, among which a complete checklist of the malacological taxa inhabiting the Strait (Granata-Grillo, 1876-1877), while a more recent and updated edition was compiled by Micali & Giovine (1983).

Numerous records of peculiar or new species at all regarded the Calabrian side of the Strait of Messina. Among all, the most recent important taxonomical studies led to the description of new taxa, i.e. *Jujubinus curinii* Bogi et Campani, 2006, *Fusinus dimassai* Buzzurro et Russo, 2007, *Gibberula* *cristinae* Tisselli, Agamennone et Giunchi, 2009. Further notes on new assessments of the malacological communities of the Strait of Messina regarded some new alien species, whose geographical distribution is expanded to this area (Crocetta et al., 2009).

In recent times new additions to the malacology of the Sicilian side of the Strait of Messina were published. Among Gastropoda some taxonomical and biological notes regarded the rare species *Melanochlamys seurati* (Vayssière, 1926), subsequently reported as *M. algirae* (Adams in Sowerby II, 1850), found at Villaggio Pace -7m, 2 liv. specimens under *Condylactis aurantiaca* (Delle Chiaje, 1825), Anthozoa Actiniaria Actiniidae (Micali & Scuderi, 2006); the taxonomical position and distribution of the opistobranch incorrectly known as *Cylichnina multiquadrata* Oberling, 1970 was re-discussed by Micali (2014), who assigned it the correct name *Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013; *Skenea giemellorum* Romani, Bogi et Bartolini, 2015 was described as new species and reported for some Italian localities, among which the Strait of Messina (Romani et al., 2015).

The bivalves *Lucinoma spelaeum* Palazzi et Villari, 2001 for the first time after hits institution as a new species (Palazzi & Villari, 2001), was recorded outside Taormina's caves, along the shores of the Strait (Micali, 2004), where an exceptional finding of the Cephalopoda *Octopoteuthis sicula* Rüppell, 1844 (Villari & Ammendolia, 2009), a problematic mesopelagic species, allowed new taxonomical considerations (Jereb et al., 2012; 2016).

Since we always had been attracted by the biological richness of the Messina's harbor, whose peculiar hook shaped form contributes to maintain a well preserved environment, also due to a very vigorous hydrodynamism, we begun to sample malacological materials for new observations. Data on species hereafter reported and commented are based on records of the sole Messina province (Fig. 1).

Some of these records represent just an expansion of the geographical distribution of some poorly known species, i.e. *Jujubinus curinii*, described only in recent time from Scilla (Reggio Calabria), and *Pitar mediterraneus* (Aradas et Benoit, 1872), reported as a good species by Gofas et al. (2011), separated by the more common *P. rudis* (Poli, 1795). The habitat preference, the external appearance of the soft parts and the likely shell growth rate are here reported for the rare *Mathilda gemmulata* Semper, 1865. Some species with an Atlantic or W-Mediterranean preference, like *Tricolia deschampsi* Gofas, 1993, *Setia slikorum* (Verduin, 1984), *Gregariella semigranata* (Reeve, 1858) are here reported for the first time or confirmed to be present in Italian waters. The systematic position of some other debated taxa are here confirmed as good species, i.e. *Alvania sororcula* Granata-Grillo, 1877 and *Setia sciutiana* (Aradas et Benoit, 1874), whose locus typicus is the Messina's Strait. While the validity of *Alvania peloritana* Aradas et Benoit, 1874 as a good species and the identity of a probable second species of *Pinctada* Röding, 1798 in the Mediterranean remain open questions. *Chelidonura fulvipunctata* Baba, 1938 is here reported as a recent new alien species for the Italian waters.

MATERIAL AND METHODS

Sampling was undertaken in June-September 2015 and materials were collected along the shores of Messina, in classic localities where Authors in the past had described their new taxa: a complete map of the sampling localities is reported (Fig. 1).

Samples were conducted by SCUBA diving and materials were collected handily with a hand-towed net method (Russo et al., 1985), modified simultaneously utilizing a brush on both shaphilic and well-lighted photophilic hard substrata, from the surface to -4/6m depth. Materials fallen into the net, with a 1 mm mesh size, were immediately stored in marine water and sorted for the identification under stereomicroscope after few minutes. Some specimens were drawn with gray and coloured pencils and then saved in 90° ethanol.

Additional material derived from preceding collecting samples by fish-nets shell-grit in the collections of both the Authors of the present paper.

ABBREVIATIONS AND ACRONYMS. h: height; liv.: living specimens; sh.: shell/shells; st.: station; AVC: Alberto Villari collection; PMC: Pasquale Micali collection; DSC: Danilo Scuderi collection; JC: Jeffreys Collection; RMNH: Rijksmuseum van Natuurlijke Historie (now NCB: Naturalis Biodiversity Center, Leiden, the Netherlands); USNM: United States National Museum.

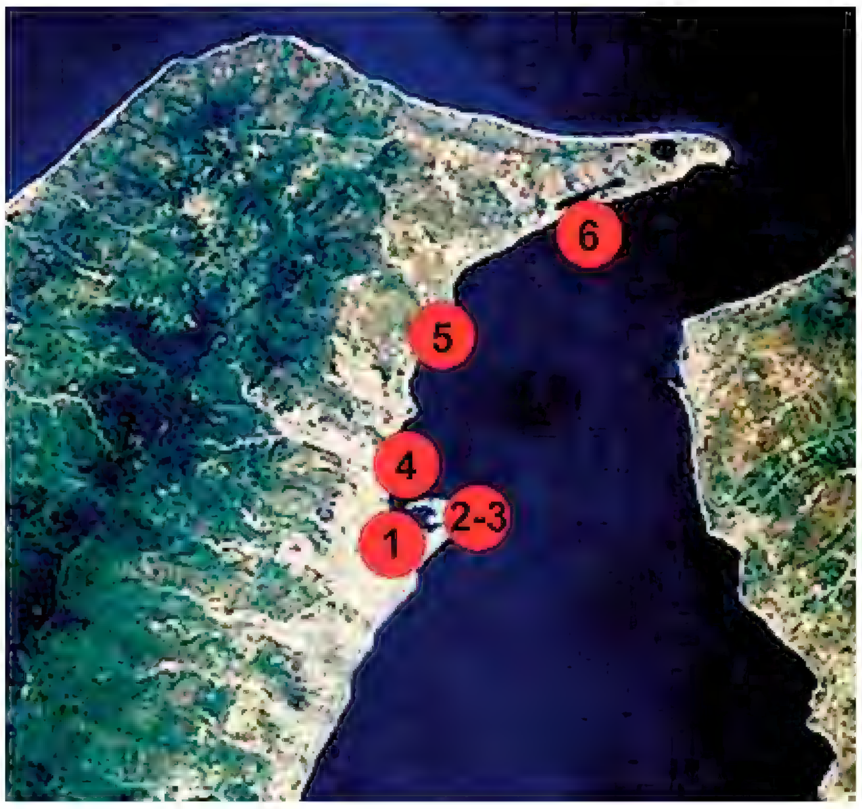


Figure 1. Study area and position of the six investigated stations: 1. Harbor of Messina; 2. S. Raineri, Maddalena Lo Faro wreck; 3. S. Raineri, "Degassifica" station; 4. Marina del Nettuno; 5. Contrada Paradiso; 6. Ganzirri.

RESULTS

Conclusions on the most interesting malacological material collected here follow. Results are grouped according to the systematic order of taxa. They vary from enlargements of geographical ranges of distribution of some species recorded to re-evaluations of the taxonomical status of some problematic taxa.

Jujubinus curinii Bogi et Campani, 2006 (Figs. 29, 30)

Examined material. st. 6, fishing nets, -100/120 m depth, one single sh., DSC; Taormina, -20 m, 12 sh., PMC.

Remarks. This species was known only for the locus typicus, the Calabrian coast of the Strait, where it was supposed to be an endemism (Bogi & Campani, 2006). According to our own data, the range of geographic distribution should be enlarged, though only inside the restricted area around the Sicilian coasts of the Strait, from Ganzirri Southern to Taormina.

Tricolia deschampsi Gofas, 1993 (Fig. 31–34)

Examined material. st. 2, 3, 5, 6, -2/4 m depth, among algae and under stones, 56 liv. and 32 sh.

Remarks. Among the "small *Tricolia* species" living in Sicily, *T. deschampsi* has never been recorded before. The exam of the external anatomy of the living animal (Fig. 34) had confirmed the taxonomical identification made after shell morphology. The species was described for the South Mediterranean part of Spain, where it was believed to be endemic, like other congeners. In recent time *T. deschampsi* has been recorded in Aegean Sea (Manousis & Galinou-Mitsoudi, 2014), although the species figured seems better to correspond to young specimens of *T. tenuis* on the basis of the colour pattern of the shell and the protoconch outline (see sketches in figures 2, 3 for comparisons). Our findings are the first for Italian waters and allowed comparisons with *T. landinii* (Fig. 35). Differences based on shell morphology, underlined by Scuderi & Reitano (2014), and on colour and anatomy of the living animal (almost entirely green in *T. landinii* and reddish-brown in *T. deschampsi*) allowed the easy distinction of the two sympatric species. Gofas (1993) reported the very similar *T. punctura* Gofas, 1993 in the Strait of Messina, which differs in colour pattern and some details of the shell.

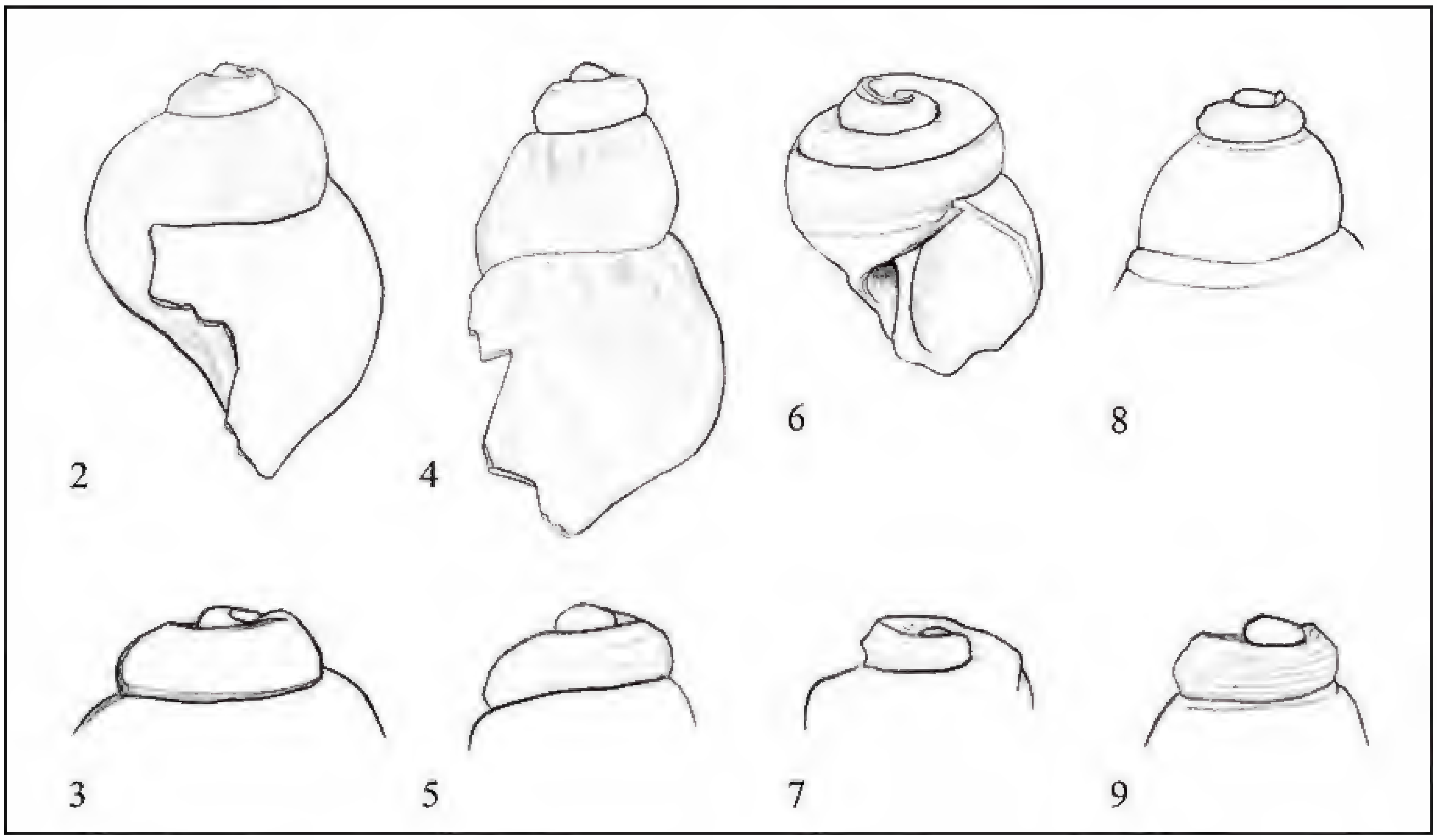
Tricolia landinii Bogi et Campani, 2007 (Fig. 35)

Examined material. st. 1, 2, 3, 4, 5, 6, -2/4 m depth, among algae, 49 liv. and 37 sh.

Remarks. The original material on which the species was described resulted constituted by young specimens, making the identification of the species problematic: only the re-description of adult specimens and the description of the external anatomical parts discriminated it rather sufficiently from all other "small *Tricolia*" and from the close similar *T. tingitana* (Scuderi & Reitano, 2014). Specimens here collected furnished useful additional informations on the shell colour pattern (Figs. 35, 36), which is almost paler and reddish than those usually found around the volcanic coasts of Catania. The colour of the living animals, paler brown in *T. deshampsi* and greenish in *T. landinii*, allows a good and quick discrimination of these two similar species.

Setia sciutiana (Aradas et Benoit, 1874) (Figs. 23–27)
Cingula kuiperi Verduin, 1984

Examined material. st. 4, -2/4 m depth, among



Figures 2–9. Sketches of young shells and protoconchs of some species of *Tricolia*. Figs. 2, 3: *T. tenuis*, Linosa Island. Figs. 4, 5: *T. miniata*, Linosa Island. Figs. 6, 7: *T. pullus*, Linosa Island. Figs. 8, 9: *T. speciosa*, Portopalo di Menfi.

algae and under stones, 25 liv. and 22 sh. *Cingula kuiperi*, holotype (RMNH.MOL.55641), El Djemila, Algeria, h: 1.6 mm (Fig. 27).

REMARKS. This species is similar to *Setia ambigua* (Brugnone, 1873) but the former could be recognised by: whorls more rounded, spire shorter, less turriculated, protoconch dome-shaped, smooth, with a dark stain umbilicus reduced to a narrow chink dark spots of the body-whorl arranged in three rows, but the lower two usually merge into one. Judging from Mediterranean checklists (Clemam, 2016; WoRMS, 2017), the taxonomical position of this species is still uncertain.

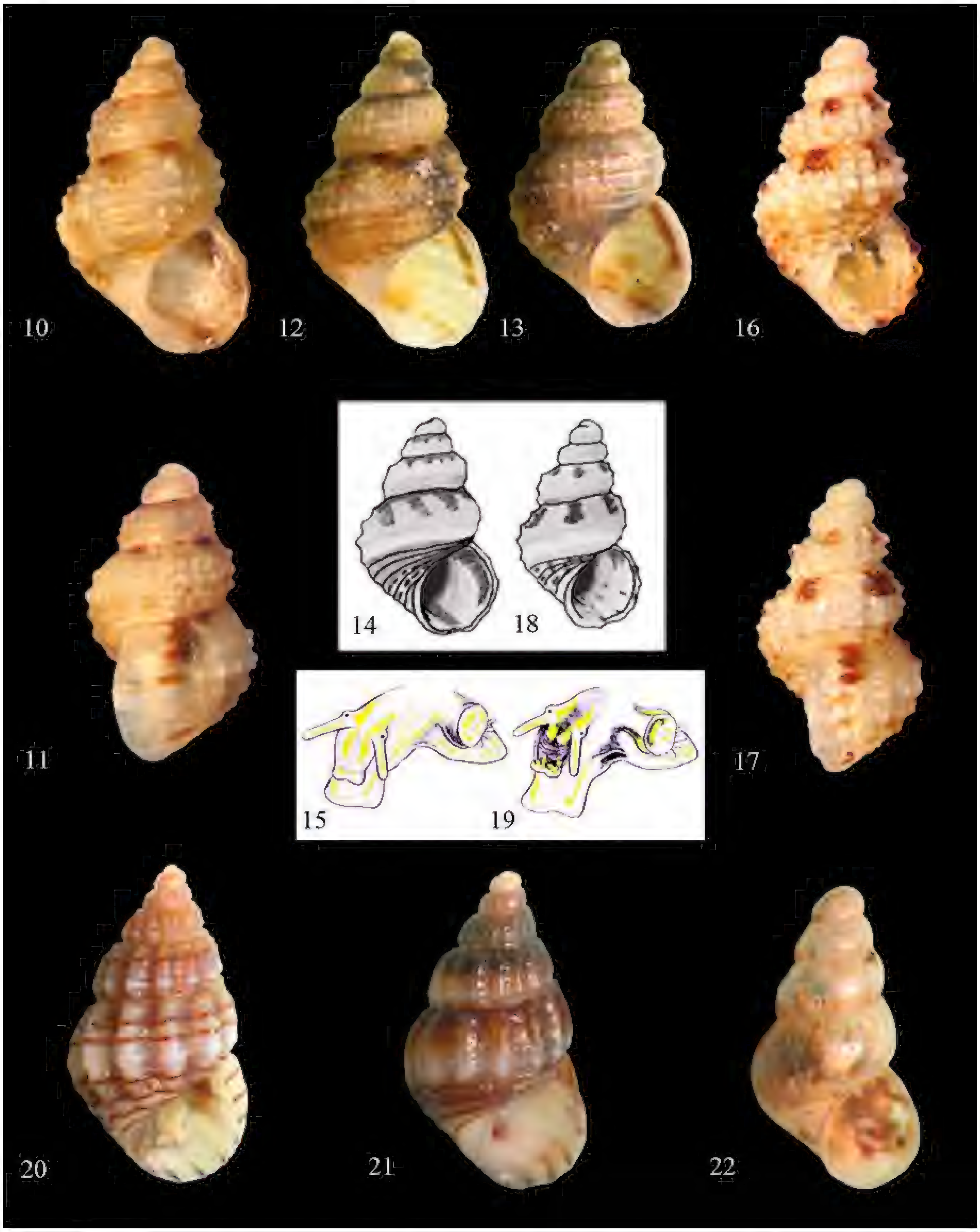
In fact it is placed among incertae sedis of Rissoidae. Probably the uncertainty which characterises the taxonomical status of the species is due to Verduin (1984), who, notwithstanding the good original diagnosis, stated the impossibility to identify this taxon without the help of the type material, which he was not able to find among the collections of several Museums. In the same paper *Cingula kuiperi* Verduin, 1984 was described from Algeria. One year after the description of this taxon, it was reported from Antibes (van der Linden & Wagner, 1985), extending its geographical distribution to France. Ten years later Gaglini (1994) reported the finding of the type material of "*Rissoa*" *sciutiana* Aradas et Benoit, 1874, which she figured and reported as valid species and possible synonym of *Setia kuiperi* (Verduin, 1984). But, one more time, the name *S. sciutiana* was not recognised as valid.

We have found numerous living specimens of this species, sympatric with the abundant congeneric *S. ambigua* from which could be separated by the almost orange-brown colour of the hepatopancreas, instead of blackish as in *S. ambigua* (Figs. 25, 26 and 28). We have found a perfect correspondence with the type material figured by Gaglini (1994). Moreover, after the comparison of the material collected with the type of *S. kuiperi* (Fig. 27), we agree with Gaglini in considering this latter species as a junior synonym of *S. sciutiana*.

Setia slikorum (Verduin, 1984) (Fig. 7)

EXAMINED MATERIAL. st. 6, -3 m, on *Caulerpa taxifolia*, 1 liv. spec.

REMARKS. This is a species of atlantic affinity usually recorded in Western-Mediterranean coasts,



Figures 10–15. *Alvania sororcula*, S. Raineri, "Degassifica" station; Figs. 11–13: variability, same data, h 2.3; 2.2 and 1.8 mm respectively. Fig. 11: shell, lateral view. Fig. 14: drawing of the shell outline and colour pattern. Fig. 15: drawing of the living animal. Figures 16–19. *Alvania scabra*, shell, same data of *A. sororcula*, h 1.8 mm. Fig. 17: lateral view. Fig. 18: drawing of the shell outline and colour pattern. Fig. 19: drawing of the living animal. Fig. 20. *Alvania lineata*, Harbor of Messina, h 3.3 mm. Fig. 21. *Alvania peloritana*, same data of *A. lineata*, h 3.2 mm. Fig. 22. *Setia slikorum*, Ganzirri, h 1.8 mm.

regularly found, but not common, in S-Spain. Few scattered records along Italian coasts are reported, which justify its presence in the Italian check-list (Oliverio, 2006), but reportedly none is really officially published. Its finding in the Sicilian waters is relevant because of its peculiarity as for environmental condition of finding and because it enlarges its geographical distribution to more Eastern localities of the Mediterranean and represents the first record for «zone 4» (the Messina's Strait) of italian checlist.

Alvania peloritana Aradas et Benoit, 1874 (Fig. 21)

Examined material. st. 1 to 6, -2/4 m depth, among algae, 36 liv. and 41 sh.

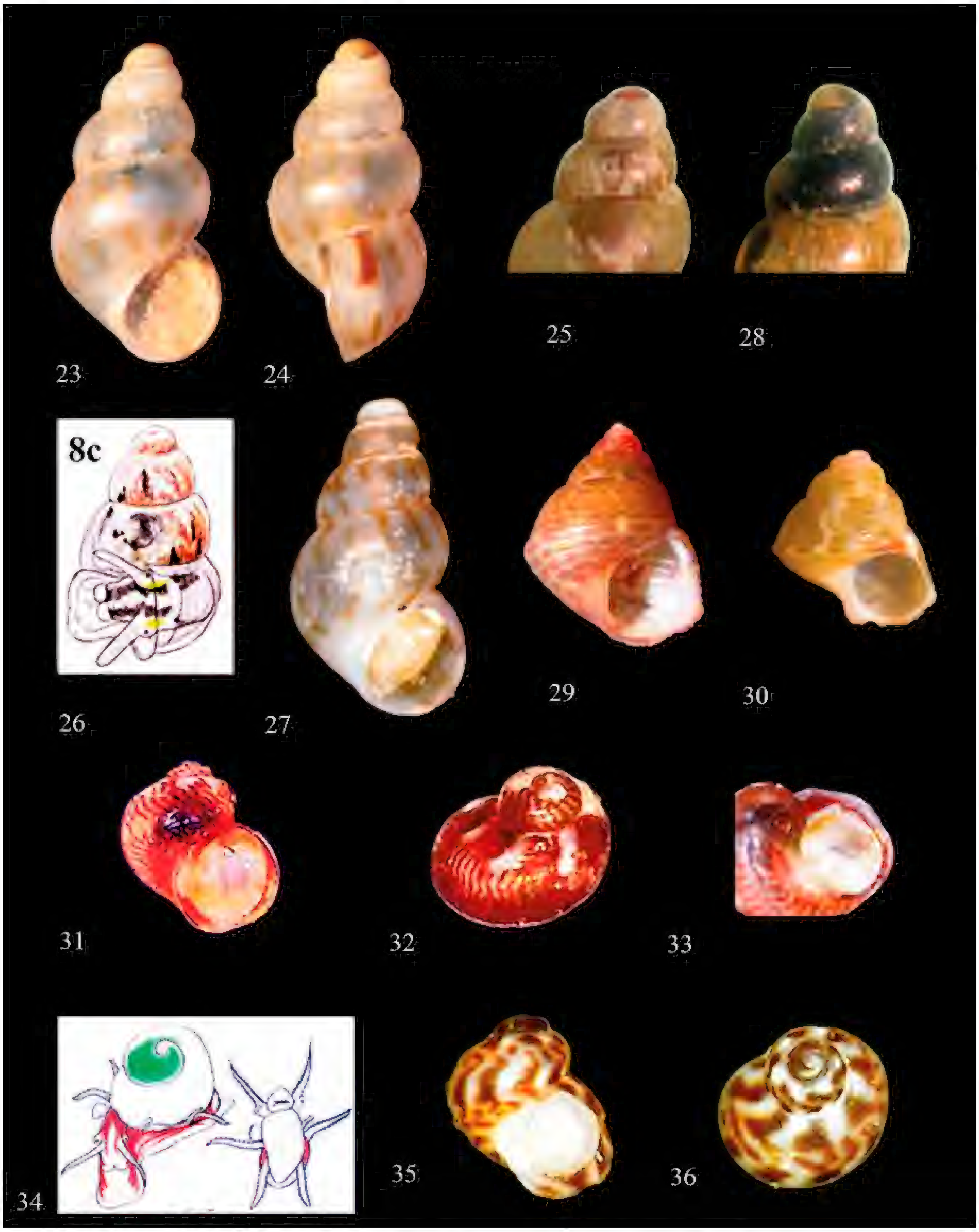
Remarks. Numerous living specimens and shells of what we interpreted as the problematic *A. peloritana* have been found along the Messina coast sympatric with the congener *Alvania lineata* (Risso, 1826) (Fig. 20). Reported as synonym of *Alvania discors* (Allan, 1818), of which *A. peloritana* recall the general shell outline, the straight and large axial ribs and the tendency of spiral chords to become faint at the top of the whorl (Scuderi & Terlizzi, 2012), it shows sufficiently marked morphological differences to be separated (Fig. 6). But the protoconch is not smooth like in *A. discors*. *Alvania peloritana* shares with *A. lineata* the general colour of the shell, the protoconch sculpture and the colour pattern of the living animal. The taxonomical problem on the correct interpretation of this species from the original diagnosis and its validity as a good separated species should be remanded to more accurate specific studies which should take in consideration the comparison with the type material.

Alvania sororcula Granata-Grillo, 1877 (Figs. 10–15)

Examined material. st. 3, -2/4 m depth, among algae, 27 liv. and 11 sh.

Remarks. The *A. scabra* (Philippi, 1844) "group" comprises several Mediterranean and Atlantic species, whose differences are questionable; the real status of single species is still debated. *Alvania sororcula* is one of them, even if we feel that among malacologists the idea of this taxon is different from the real one. Good SEM pictures of shell and protoconch of a specimen sent to Jeffreys by Granata-Grillo (USNM) and some brief comments were published by Gofas & Warén (1982: p. 4, see remarks under *A. jeffreysi* Waller, 1864), who considered it as valid. Our findings fit rather satisfactory with this latter and we agree with him in considering *A. sororcula* as a good species, which could be distinguished from *A. scabra* (Figs. 16–19), by the following differences, summarized in the sketches of figures 14 and 18: shell higher (2.4 mm vs. 1.8 mm). Different teleoconch proportions: h 0.83 vs. 0.61, with wider base. Different teleoconch sculpture: three main spirals per whorl except for the first, which bears only two; spirals are predominant over the axial ribs, with faint or no knobs at the intersection; wide smooth subsutural zone. Protoconch bigger, but with similar sculpture. Colour pattern of the shell similar, but different in some ways, being markedly bi-coloured in every whorl, with chestnut brown lower half and a grayish upper part, with characteristic dark brown subsutural alternating and prosocline stains, instead of few bigger and not inclined almost brown stains, even if almost entirely brown shells are known of both species. A wide dark band is present at the internal side of the base, instead of some rows of little points. A wider dark stain could be seen on the external lip, below the suture, just near the outer edge of the aperture. The external soft body parts are similar, but in *A. sororcula* the colour pattern is constantly less shiny, with only grayish bands, which are almost black in *A. scabra* (Fig. 19).

Comparative notes. The numerous shells and living specimens collected allowed us to confirm the above mentioned taxonomical status of the species and to compare it to close similar species. Starting by saying that all these considerations are based on morphological characters only and that the taxonomy of this complicated group of *Alvania* needs a more accurate revision with molecular approach, according to our observations *A. sororcula* could be easily separated from typical *A. scabra* s.s., from *A. lucinae* Oberling, 1970 and from *A. oranica* (Pallary, 1900) by the absence of the fourth spiral chord in the whorls preceding the last, which leaves a wide abapical steep zone and shapes the whorls characteristically pagoda-shaped and not almost rounded (see for instance figures 14 and 18). In the Mediterranean only *A. sculptilis* (Monterosato, 1877) resembles *A. sororcula*. Speaking about *A. sculptilis*, Tringali (2001) described



Figures 23-26. *Setia sciutiana*, Marina del Nettuno, h 1.55 mm; Fig. 24: shell, lateral view; Fig. 25: detail of the protoconch shape and colour of hepatopancreas; Fig. 26: drawing of the living animal. Fig. 27. "*Cingula*" *kuiperi*, holotype (RMNH.MOL.55641), 1.6 mm. Fig. 28. *Setia ambigua*, Marina del Nettuno, h 1.75 mm, detail of the protoconch and colour of hepatopancreas. Figs. 29, 30. *Jujubinus curinii*, Ganzirri, h 3.8 mm; Fig. 30: Taormina, h 1.4 mm (PMC). Figs. 31-34. *Tricolia deschampsi*, S. Raineri, Maddalena Lo Faro wreck, h 1.2 mm; Fig. 32: upper view; Fig. 33: detail of the outer lip and operculum. Fig. 34: drawing of the living animal. Figs. 35, 36. *Tricolia landinii*, S. Raineri, Maddalena Lo Faro wreck, h 1.3 mm; Fig. 36: upper view.

and figured very well the shell and protoconch, distinguishing it from *A. scabra*. Of this latter he showed good figures too of the shell and protoconch (a specimen from a submarine cave from Capo Palinuro, Italy), which however does not perfectly match with our own idea and figures of *A. scabra*. Tringali (2001) concludes its note to *A. sculptilis* hypothesizing that the Western Mediterranean form, corresponding to *A. sculptilis*, is separable by the Central Mediterranean one, which corresponds to *A. scabra* s.s. if it will be proved the lack of intermediate forms. He never mentions nor compares *A. sculptilis* to *A. sororcula*. Concerning *A. oranica*, therefore, Tringali (2001) seems convinced that this latter species, which should bear a spiral chord more on the penultimate whorl in some specimens, should be the same of *A. sculptilis* too, being the presence of the fourth spiral chord a rather variable character on account of his experience. According to us *A. sculptilis* could be the same as *A. sororcula*, even if some little differences could be detected (see Gofas et al., 2011: 183). *Alvania oranica* should be a different species, which could represent at least a Western Mediterranean cline of *A. scabra*, being intermediates maybe constituted by a third still undescribed species.

If the identity between *A. sororcula* and *A. sculptilis* will be demonstrated, the former should be considered junior synonym, the description of the taxon being published on August 1877 (see Bertolaso & Palazzi, 1997), while that of *A. sculptilis* was publicated on genuary of the same year (Clemam, 2016). But this latter is a secondary homonym of *A. sculptilis* (May, 1920), an Australian species for which seem more useful to be employed (see Criscione & Ponder, 2011 and comments on WoRMS, 2017).

BIOLOGY AND DISTRIBUTION. Shallow water, among algae. The deeper findings of some collectors are probably due to dead specimens falling down from shallow waters by the strong sea currents or to misidentifications of the species.

Mathilda gemmulata Semper, 1865 (Figs. 37–40)

EXAMINED MATERIAL. st. 1, -2/4 m depth, among algae and under stones, 14 liv. and 2 sh.

REMARKS. This rather infrequent species was taxonomically treated by Oliverio & Nofroni (1986), who listed and critically commented a series of synonyms. We agree with actual point of view of modern checklists (see WoRMS, 2017) in considering *M. barbadensis* Dall, 1889 as a distinct species, being more conical in general outline, with a different proportion between the height of the last whorl and that of the spire, more pointed, having a proportionally smaller protoconch, and with a more marked central chord, which excels over the others. Specimens of *M. gemmulata* Semper, 1865 collected in the present paper have been recorded in shallow waters, on the shaphilic side of the harbor's piers, which lie on sandy bottom, where some sea anemones of different species were present and upon which it probably feeds. As additional data on this species, here we present two photographs of the living animal (Figs. 39, 40) since, at our knowledge, no pictures of this species are present in literature

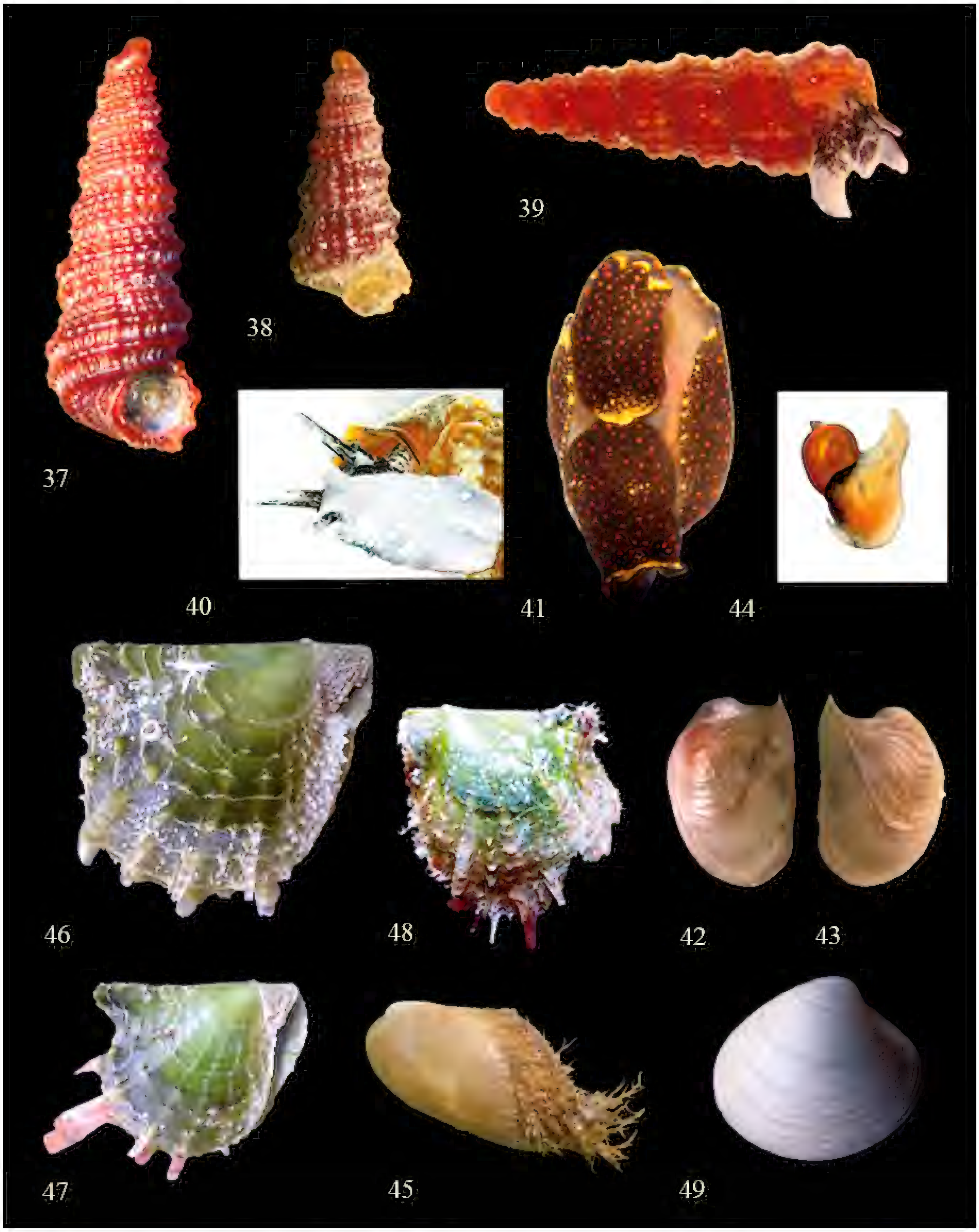
Chelidonura fulvipunctata Baba, 1938 (Figs. 41–43)

EXAMINED MATERIAL. st. 3, under small rocks, -2m depth, one single specimen.

REMARKS. A single specimen of an undetermined Aglajdae was collected alive. The general shape of the living specimen suggested that it belongs to the genus *Chelidonura* A. Adams, 1850. But none of the known Mediterranean species seemed to correspond to the characteristics of the specimen found, for the higher dimensions, the brown colour, mottled of small orange stains, except for the head, which bears a marked whitish "W" on the anterior part of the shield. Further studies allowed us to name it as *C. fulvipunctata*, an alien species which entered into the Mediterranean only in recent times and was recorded for the first time in Turkey and reported as *Chelidonura mediterranea* (Swennen, 1961) new species.

The internal very small and fragile shell is wider and bigger in dimension compared to that of the other Mediterranean species, which are thinner and very reduced. In particular it is different in colour pattern, dimensions and internal shell from *C. italica* Sordi, 1980, which name is to be used instead of *C. africana* Pruvot-Fol, 1953 as stated in Perrone & Sammut (1997), with whom we agree and which we found sympatrically in the same site (Fig. 44).

Mediterranean records of this species are scanty and regard mainly Eastern regions: see Tsiakkiros



Figures 37-40. *Mathilda gemmulata*, Harbor of Messina, h 5.0 mm; Fig. 38: younger specimen, h 3.5 mm; Figs. 39, 40: living animal, h 5.3 mm. Figures 41-43. *Chelidonura fulvipunctata*, S. Raineri, "Degassifica" station, living animal, h 26 mm; Figs. 42, 43, upper and lower view of the internal shell, h 6 mm. Fig. 44. *Chelidonura italica*, S. Raineri, "Degassifica" station, lower view of the internal shell, h 0.46 mm. Fig. 45. *Gregariella semigranata*, Harbor of Messina, h 2.1x3.4 mm. Figures 46-48. *Pinctada* sp. aff. *radiata*; Figs. 46, 47: Playa di Catania, h 28 and 21 mm; Fig. 48: Contrada Paradiso, h 40 mm. Figure 49. *Pitar mediterraneus*, Ganzirri, h 13.5x15 mm.

& Zenetos (2011), who collected it at Cyprus, for a more complete list of collecting localities. In recent time it was found at Malta (Perrone & Sammut, 1997).

Gregariella semigranata (Reeve, 1858) (Fig. 45)

EXAMINED MATERIAL. st. 1, on algae of break waves, -1/2m depth, one single specimen.

REMARKS. This species too is usually recorded in Western-Mediterranean coasts. Its scattered records into the Mediterranean could be linked to anthropic activities, since findings are accompanied with other Atlantic species in localities often interested by a very busy naval traffic (personal observations).

Pinctada sp. aff. ***radiata*** (Figs. 46–48)

EXAMINED MATERIAL. st. 5, *Posidonia* mattes, -7 m, 15 sh.

REMARKS. *Pinctada radiata* is one of the earliest introduced Indo-Pacific species in the Mediterranean sea thRought the Red sea, being the first record reported by Monterosato as *Meleagrina savignyi* Monterosato, 1884 from Egypt (Monterosato, 1878). Subsequently this species was regularly found along all the Mediterranean sea and the Italian coasts (Parenzan, 1961; Bombace, 1967; Paccagnella, 1967; Spada, 1969). Nowadays the distribution of the species in this basin is rather wide but inconsistent as for number of specimens collected in single localities. Only in some North-African sites it seems abundant. In Lampedusa Island (Pelagie Islands) it is well established in shallow rocky shores till today. Young specimens of this species were found attached on the carapace of the sea turtles (Oliverio et al., 1992), though its distribution in the Mediterranean is not proved to be linked to the movements of these marine reptiles.

In recent times a new massive invasion of this species seems to proceed along the Ionian coasts of Sicily. Two years ago several thousands of living specimens (Figs. 46–47) were beached at Playa of Catania after a storm, where, judging by the literature data, the species was never found before since Aradas & Benoit (1872–74) till today (personal data), with the exception of a single record for the external wall of the harbor of Catania (Di Geronimo, 1971: based on material of Priolo collection). Specimens found in Catania are identical to those found inside the lake of Ganzirri and just out of there, along the Messina's shores (Fig. 48). All this materials is constituted by specimens, which morphologically seem to differ from specimens of typical *P. radiata* from Southern Mediterranean localities.

In particular specimens here reported differ for: valves more convex; less flattened profile seen from the umbo; shell colour tending from yellowish-green to deep green; only 5, 6 main ribs on the right valve, with a series of 4–6 more minute ribs on the posterior margin of the same valve; spiny process less numerous and more robust, even on the left valve (Fig. 48).

One additional character could be detected observing some small differences of the hinge tooth of both the valves, less robust and better defined in *P. radiata* s.s. But these last observations need more accurate studies to be confirmed. On the other hand, a more accurate anatomical exam has revealed the presence of a speare-shaped anal funnel typical of the *P. imbricata* Röding, 1798 group (Gervis & Sims, 1992), to which some geographically different clines seem to merge. In fact *P. imbricata radiata* (Leach, 1814) is the name nowadays used for this alien species, though it is not clear whether a single cline from a specific geographic area could be considered a separated species or not (Temkin, 2010). Molecular data support the validity of some groups only (Temkin, 2010), even if large reshuffling of clines (or species?) happens in single geographic regions, due to actual very intensive ship traffic, which renders more complicated every further investigations.

Pitar mediterraneus (Aradas & Benoit, 1872) (Fig. 49)

EXAMINED MATERIAL. st. 4, on sandy bottom, -7 m depth, 2 liv.

REMARKS. Considered a simply chromatic variation of *Pitar rudis* (Poli, 1795), only in very recent time it was considered a different species (Gofas et al., 2011), not only on the basis of the entirely white colour of the shell and the general more globose outline, but even of the shell sculpture, different arrangement of the hinge's teeth and habitat characteristics.

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Biodiversity Journal, 2017, 8 (1): 205–210

MONOGRAPH

Description of a new species of the genus *Raphitoma* Bellardi, 1847 from the Mediterranean Sea (Mollusca Neogastropoda Conoidea Raphitomidae)

Francesco Pusateri[1], Riccardo Giannuzzi Savelli[2*] & Peter Stahlschmidt[3]

[1]via Castellana 64, 90135 Palermo, Italy; e-mail: francesco@pusateri.it
[2]via Mater Dolorosa 54, 90146 Palermo, Italy; e-mail: malakos@tin.it
[3]University of Koblenz-Landau, Institute for Environmental Sciences, Fortstraße 7 - 76829 Landau, Germany; e-mail: stahlschmidt@uni-landau.de
[*]Corresponding author

ABSTRACT The family of Raphitomidae is currently considered a well supported clade of the Conoidea. The type genus *Raphitoma* Bellardi, 1847 is well known in the mediterranen Seas with about 40 species, some of which are still undescribed. Morphological analyses carried out on the genus *Raphitoma* Bellardi, 1847 (Mollusca Neogastropoda Conoidea Raphitomidae) from Mediterranean Sea allowed to identify a new species which is described in the present paper.

KEY WORDS *Raphitoma*; Conoidea; new species; Mediterranean Sea.

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INTRODUCTION

The Raphitomidae Bellardi, 1875 are currently considered a well supported clade of the Conoidea (Bouchet et al., 2011).

The superfamily Conoidea, with over 300 genera and 4,000 recognised species, but probably over 12,000 extant species (Bouchet, 1990; Tucker, 2004), represents the largest radiation of the entire phylum Mollusca. In a work on the phylogeny of the group based on a cladistic analysis of foregut morphology, Taylor et al. (1993) have highlighted the rampant homoplasy in the characters of shell and radula in conoideans.

Accordingly, they have rearranged most of the conoideans into two families: Conidae, comprising Coninae and 4 subfamilies traditionally considered as "turrids", and Turridae s.s. including some of the traditional "turrids". More recently, Puillandre et al. (2008) and Bouchet et al. (2011), based on DNA phylogeny, have provided a major update of conoidean classification. Although a larger taxonomic coverage would be desirable to further stabilize the molecular phylogeny, however, the position of the Raphitomidae as a clade of the Conoidea is sufficiently supported.

The taxon Raphitomidae is based on the genus *Raphitoma* Bellardi, 1847 which was introduced as comprising 30 fossil and Recent species (Bellardi, 1847: 85), previously classified in various genera (such as *Pleurotoma* Lamarck, 1799 and *Clathurella* Carpenter, 1857).

Among the modern authors, Nordsieck (1977) listed 30 european species of Raphitomidae plus several subspecies and varieties. In the revision of the mediterranean Raphitomidae that we are currently carrying out, we estimated about 40 mediterranean species, some of which are still to be described (see Pusateri et al., 2016).

ABBREVIATIONS AND ACRONYMS. CAH: André Hoarau collection (Fréjus, Francia); CFP: Francesco Pusateri collection (Palermo, Italy); CGN: Giuseppe Notaristefano collection (Messina, Italy); CJD: Jean Louis Delemarre collection (Saint Nazaire, France); CMM: Max Marrow collection (Melbourne, Australia); CPO: Panayotis Ovalis collection (Athens, Greece); CPS: Peter Stahlschmidt collection (Landau, Germany); CAR: Alessandro Raveggi collection (Firenze, Italy); CRA: Roberto Ardovini collection (Rome, Italy); CRO: Rosario Occhipinti collection (Ragusa, Italy); MBMPRC: Museo di Biologia Marina e Paleontologia di Reggio Calabria; MCZR: Museo Civico Zoologia Roma (Rome, Italy); MNHN: Museum National d'Histoire Naturelle (Paris, France); h: height; sh: shell/s; Std: standard deviation; D: diameter.

RESULTS

Systematics

Citation of unpublished names is not intended for taxonomic purposes.

Classis GASTROPODA Cuvier, 1795
Subclassis CAENOGASTROPODA Cox, 1960
Ordo NEOGASTROPODA Wenz, 1938
Superfamilia CONOIDEA Fleming, 1822
Familia RAPHITOMIDAE Bellardi, 1875
Genus *Raphitoma* Bellardi, 1847

Type species: *Pleurotoma hystrix* Cristofori et Jan, 1832 (*nomen nudum*, validated by Bellardi, 1847 as "*Pleurotoma histrix* Jan.") by subsequent designation (Monterosato, 1872: 54).

Raphitoma ephesina n. sp.
= *Raphitoma rugosissima* Monterosato ms.

EXAMINED MATERIAL. Type material: Holotype (Bozcaada Island, Turkey) -95 m, mm 5.7 x 2.7 (MNHN); paratype A (Saronic Bay, Aegean Sea, Greece), mm 5.8 x 2.9 (CFP); paratype B (Bozcaada Island), mm 7.2 x 3.5 (MNHN); paratype C (Veli Rat, Dugi Otok Island, Croatia), mm 7.1 x 3.6 (CFP); paratype D (Scilla, Reggio Calabria, Italy), -52 m "*alla base del Secondo Dente di Skylla*" (38°15'25,05"N - 15°42'46,11"E), mm 5.3 x 2.7 (MBMPRC, legit A. Vazzana).

OTHER MATERIAL EXAMINED. France. St. Raphael, 2 sh (CAH).

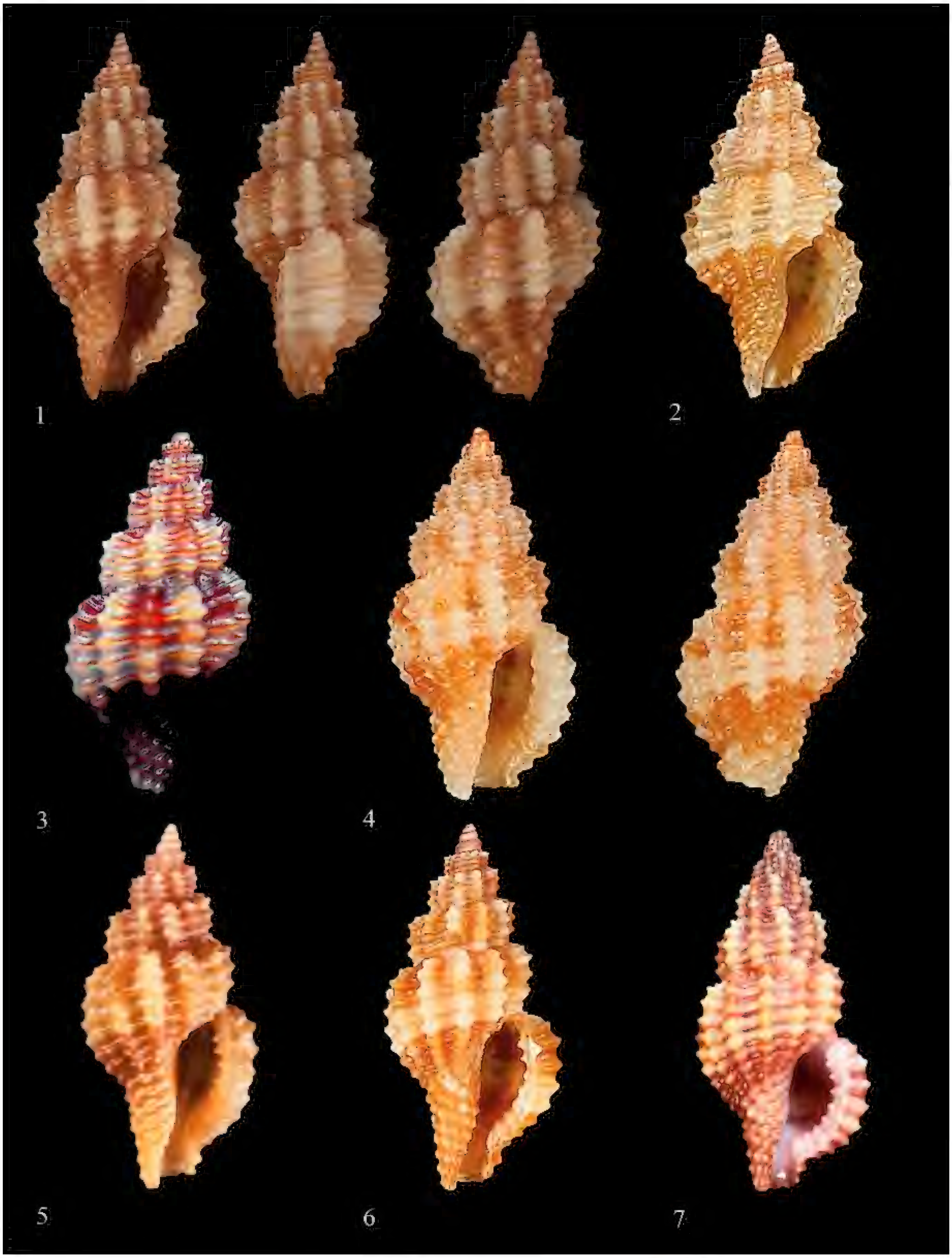
Italy. Porto Venere (La Spezia), 3 sh (CMM); Sardegna, 1 sh (CRA); Scilla, Reggio Calabria, -52 m "*alla base del Secondo Dente di Skylla*", 38°15'25.05"N - 15°42'46.11"E, 3 sh. (MBMPRC, legit A. Vazzana); Milazzo, 1 sh (CGN); Trapani, 1 sh (CRA)

Croatia. Veli Rat - Dugi Otok Island, 6 sh (CFP), 1 sh. coll. Monterosato lot 16468 sub nomine R. *rugosissima* ms. (MCZR), sine loco, 1 sh (CJD).

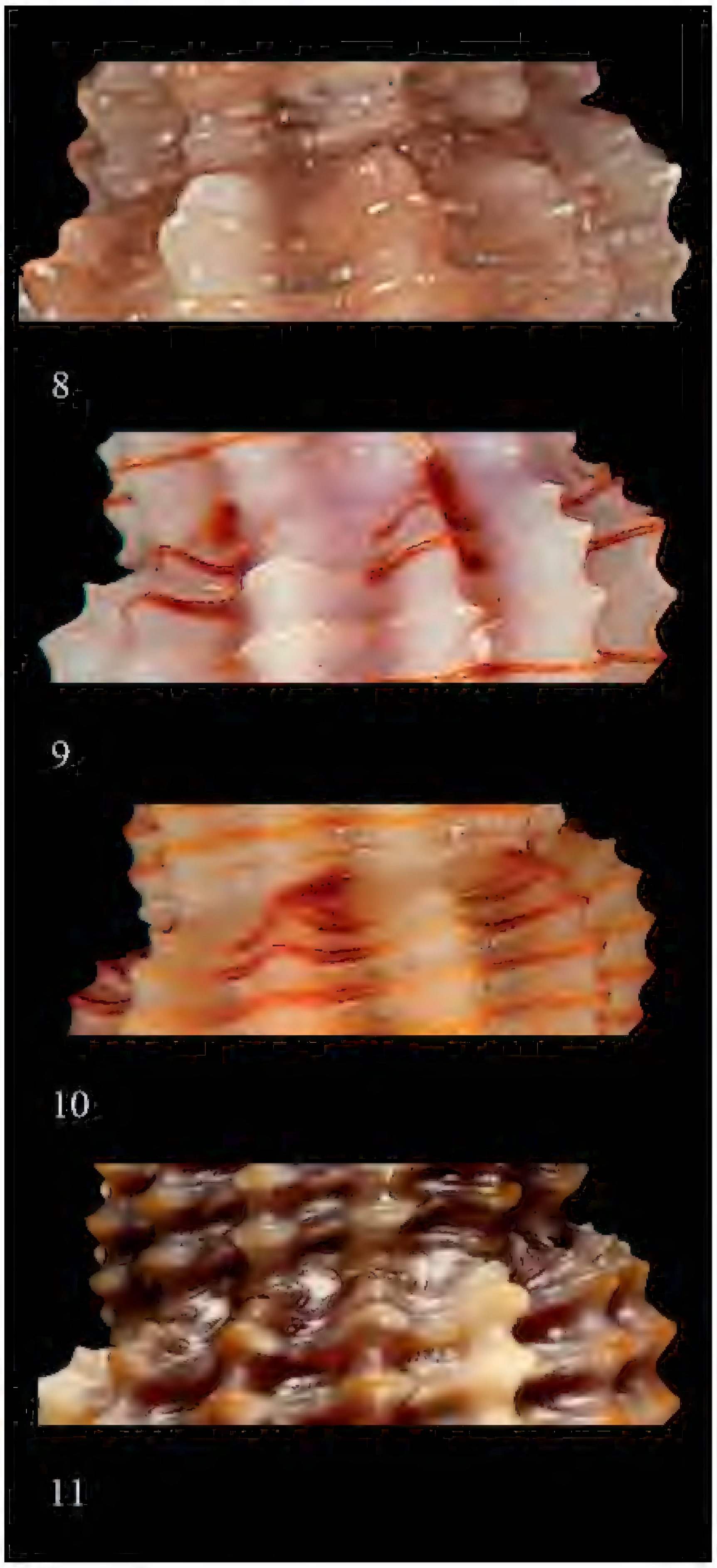
Greece. Evia Island (Aegean Sea), 1 sh (CPO); Saronic Bay, 1 sh (CPO); Kolovri Islet, Corfù, 3 sh (CAR).

Turkey. Bozcaada Island, 1 sh (CPS); 3 sh (CRO).

DESCRIPTION OF HOLOTYPE. Shell of small size for the genus, height 5.7 mm, width 2.7 mm, biconical with slender upper part, H/D 2.11. Protoconch multispiral of 3.6 convex whorls, height 520 µm, width 430 µm; protoconch I of 1 whorl, width 175 µm, with cancellate sculpture of orthocline axials and spirals of equal strength; protoconch II of 2.6 whorls, with diagonally cancellate sculpture on the lower two thirds, and subsutural orthocline axials on the upper third. Teleoconch of 4.5 sligthly convex whorls. Suture not incised, evident. Axial sculpture of 10 slightly prosocline elevated and strong ribs, and interspaces broad as the ribs. Spiral sculture of 5 prominent cordlets on the penultimate whorl, (the first, subsutural, weak) thinner that axial ribs and interspaces four times as broad as the cordlets. Cancellation horizontally rectangular, deep with semitransparent back wall. The second cordlet at the intersection with the ribs form tubercles more acute than others with a mammillary appearance. Subsutural ramp very short. Columella simple, slightly sinuous anteriorly and gently angled posteriorly. Outer lip thickened and crenulated externally with 7 strong inner denticles, the most anterior larger. Anal sinus evident but not deep, Siphonal canal long, wide, funnel like. Siphonal fasciole of 7 nodulose strong cordlets. Background and cordlets color usually soft cherry



Figures 1–7. Shells of *Raphitoma ephesina* n. sp. Fig. 1: holotype, Bozcaada Island, Turkey (MNHN, h: 5.7 mm); Fig. 2: paratype A, Saronic Bay, Greece (CFP, h: 5.8 mm); Fig. 3: Saronic Bay (Greece (CPO, h: 6.7 mm); Fig. 4: paratype C, Velirat Isl., Croatia (CFP, h: 7.1 mm); Fig. 5: paratype D, Scilla, Reggio Calabria, Italy (MBMPRC, h: 5.3 mm); Fig. 6: Trapani, Italy (CRA, h: 6 mm); Fig. 7: St. Raphael, France (CAH, h: 7.5 mm).



Figures 8–11. Particulars of cordlets of *Raphitoma*. Fig. 8: *R. ephesina* n. sp.; Fig. 9: *Raphitoma linearis* (Montagu, 1803); Fig. 10: *Raphitoma aequalis* (Jeffreys, 1867); Fig. 11: *Raphitoma bicolor* (Risso, 1826).

except the over sutural cordlet which is white. The summit of the cordlets resumes the background color. Many ribs are white or withish. The lower part of the last whorl is evenly soft cherry. Soft parts are unknown.

VARIABILITY. Height 5–7.5 mm (mean 6.2, std 0.62), width 2.5–3.7 mm (mean 3.06, std 0.36), H/D 1.86–2.14 (mean 2.02, std 0.08); axial sculpture of 9-12 ribs (mean 11, std 1.27); outer lip with 7 denticles, siphonal fasciole with 7 nodulose cordlets (exceptionally 6). The colour range from light to dark cherry.

ETYMOLOGY. Dedicated to goddess Artemis of Ephesus, called "the polimastic" because of the four rows of breasts that cover the bust which recall the sculpture of this new species.

DISTRIBUTION. The new species is widely distributed in the Mediterrean Sea (so far known form France, Italy, Croatia, Greece, and Turkey).

REMARKS. For some of its conchological features *R. ephesina* n. sp. is akin to the group of *R. linearis* (Montagu, 1803)-*R. aequalis* (Jeffreys, 1867). It shares a similar shell size, profile, the prominent cords with the colored top, the same number of protoconch whorls (3.6), and the almost equal protoconch dimensions.

In particular it differs from *R. linearis* by the lack of microgranules in sculpture, by the number of cordlets on the penultimate whorl (5 vs. 4). The top of the cordlets of *R. linearis* is colored, sometimes strongly, only in the first two subsutural and fourth. It also differs in the background color which in *R. linearis* is generally cream or whithish with the first whorls slightly purple and in the color of protoconch which is white. The denticles of *R. linearis* are barely noticeable only in gerontic specimens while they are clearly visible in *R. ephesina* n. sp.

It differs from *R. aequalis*, by the lack of microgranules in sculpture and by the number of cords on the penultimate whorl (5 vs 6–7). In *R. aequalis* cordlets are always brown colored except those next to the suture which are white coloured.

Also it differs for the background color and that of the protoconch that in *R. aequalis* are generally whitish.

Raphitoma ephesina n. sp. could eventually be confused with juveniles of *R. bicolor* but their protoconchs are quite different (see figures 12 and 15).

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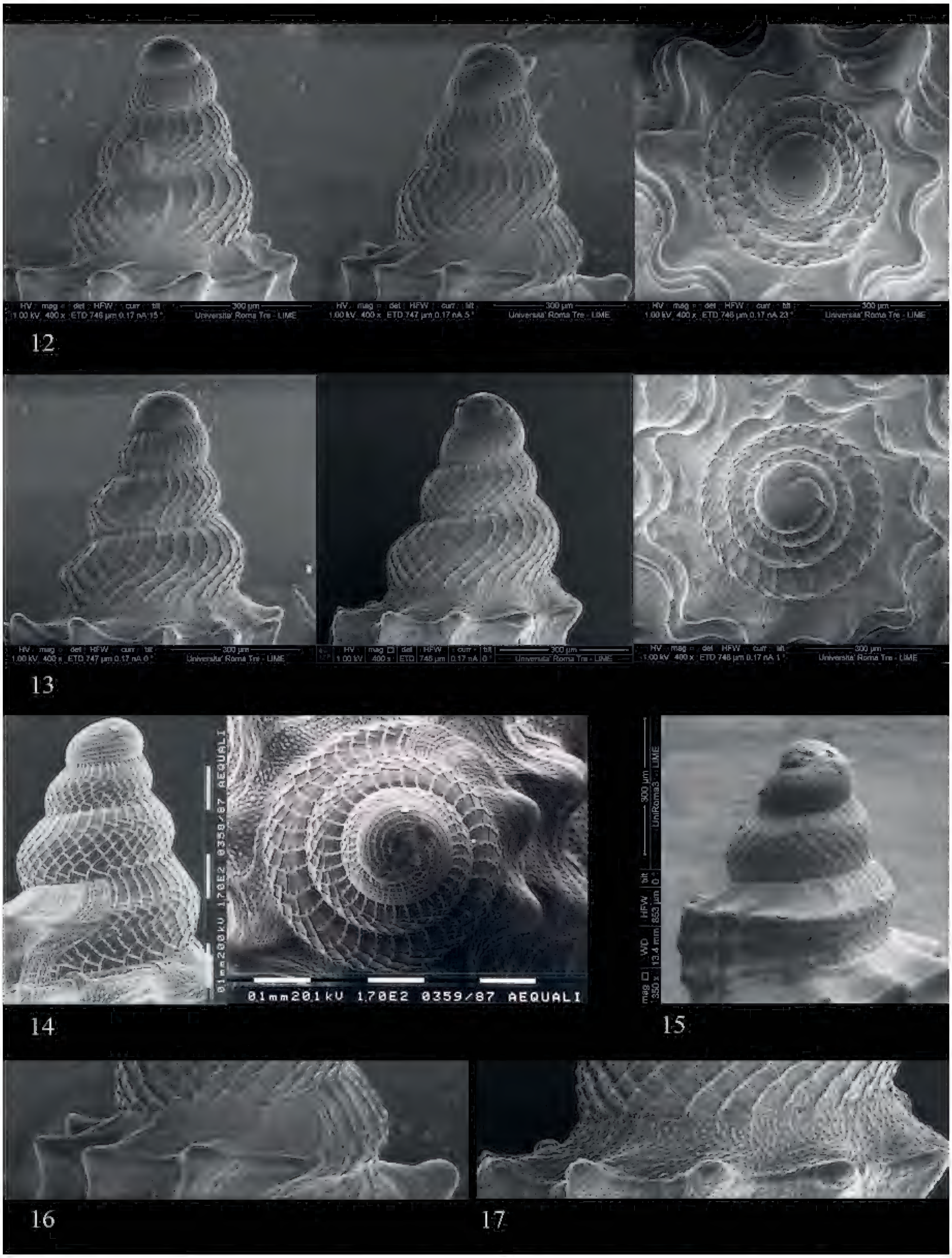
Sincere thanks are due to Roberto Ardovini (Rome, Italy), André Hoarau (France), Max Marrow (Melbourne, Australia), Andrea Nappo


300 µm
Universita' Roma Tre - LIME
12
13
0 1 m m 2 0 1 k V 1 7 0 E 2 0 3 5 9 / 8 7 A E Q U A L I
0 1 m m 2 0 0 k V 1 7 0 E 2 0 3 5 8 / 8 7 A E Q U A L I
14
300 µm
UniRoma3 - LIME
15
16
17

Figures 12–15. Protoconchs: 12: *Raphitoma ephesina* n. sp.; 13: *Raphitoma linearis*; 14: *Raphitoma aequalis*; 15: *Raphitoma bicolor*. Figures 16–17: Particulars showing lacking (Fig. 16: *R. ephesina* n. sp.) and presence (Fig. 17: *R. linearis*) of micro-granules on the shell surfaces

(Cagliari, Italy); Rosario Occhipinti (Ragusa, Italy), Panayotis Ovalis (Athens, Greece), Angelo Vazzana (Reggio Calabria, Italy) for having placed materials or photos at our disposal. We would like to express our gratitude to Stefano Bartolini (Firenze, Italy) for the light photographs, SEM photograph were done by Andrea Di Giulio (Department of Biology, "Roma Tre" University, Rome, Italy) at the "LIME" (Interdepartmental Laboratory of Electron Microscopy) and by Bruno Sabelli at Bologna University, Giuseppe Bagnera (Palermo, Italy) for the drawings, Floriana Giannuzzi Savelli (Palermo, Italy) for computer consulting, Paolo Mariottini (Rome, Italy), Carlo Smriglio (Rome, Italy), Danilo Scuderi (Catania, Italy) and Marco Oliverio (Rome, Italy) for their valuable help.

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Biodiversity Journal, 2017, 8 (1): 211–238

MONOGRAPH

Land mollusks of Chalki and Alimia (Dodecanese Archipelago, Greece)

Fabio Liberto[1*], Mauro Grano[2], Cristina Cattaneo[3] & Salvo Giglio[4]

[1]Via del Giubileo Magno 93, 90015 Cefalù, Italy; email: fabioliberto@yahoo.it
[2]Via Val Cenischia 24, 00141 Rome, Italy; email: elaphe58@yahoo.it
[3]Via Eleonora d'Arborea 12, 00162 Rome, Italy; email: cristina.cattaneo76@libero.it
[4]Contrada Settefrati, 90015 Cefalù, Italy; email: hallucigenia@tiscali.it
[*]Corresponding author

ABSTRACT A check list of land snails of the island of Chalki and the nearby islet of Alimia (South Aegean Greece, Dodecanese Archipelago) is given. The literature concerning the non-marine mollusks living on the two islands is critically reviewed. New data on morphology of some snails species are presented, with particular account to the genus *Rhabdoena* Kobelt et Mollendorff, 1902, *Zebrina* Held, 1838 and *Albinaria* Vest, 1864.

KEY WORDS Land snails; endemism; Dodecanese Islands; Chalki; Alimia.

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INTRODUCTION

The malacological researches on Chalki Island and Alimia Islet began in 1887 with the naturalistic surveys of Eberhard Von Ortzen, carried out in the Aegean Islands and in the southwest corner of Asia Minor with the support of the Royal Prussian Academy of Sciences. The Von Ortzen's collections of terrestrial mollusks were later studied by the German malacologists Oscar Boettger and Eberh Von Martens.

Boettger (1889) published a monograph on Clausiliidae describing several new species, including a new subspecies of *Albinaria brevicollis* (L. Pfeiffer, 1850) endemic to Chalki *A. brevicollis chalcidensis* (O. Boettger, 1889).

In the same year Von Martens (1889) published the first comprehensive survey of the mollusks of the Aegean Islands and Asia Minor, reporting for the island of Chalki nine species of terrestrial mollusks: *Hyalina aequata* Mouss., *Helix* (*Pseudocampylaea*) *pellita* Fer., *Helix* (*Iberus*) *spiriplana* Oliv., *Helix* (*Pomatia*) *aperta* Born, *Helix* (*Xerophila*) *cretica* Pfr., *Bulimus* (*Mastus*) *turgidus* Kobelt, *Pupa* (*Orcula*) *scyphus* Pfr., *Clausilia* (*Albinaria*) *brevicollis* Pf., *Clausilia* (*Albinaria*) *teres* (Oliv.) var. *extensa* Pfr.

Gude (1902) published a list of the Helicoid land snails of Asia, listing for the island of Chalki the Von Martens's data for this group: *Retinella aequata* Mouss., *Helicella* (*Heliomanes*) *cretica* Pfr., *Hygromia* (*Metafruticicola*) *pellita* Fér., *Helix* (*Levantina*) *spiriplana* Oliv., *Helix* (*Helicogena*) *aperta* Born.

Of particular significance is the work of Gambetta (1929), as this was the first comprehensive study of the mollusks of the Dodecanese Islands as a whole. Her research was based on material resulting from extensive samples carried out by Festa (1913), Desio (1922–1924), Ghigi-Issel (1928–1929). Part of the specimens collected by Ghigi were complete with soft parts, and this material allowed Gambetta to study for the first time the anatomy of some species. Gambetta reviewed most of the previous literature on the Dodecanese non-marine mollusks and listed 106 species for the Dodecanese Islands and 11 species for Chalki Island:

Hyalinia (*Eopolita*) *aequata* Mousson, *Metafruticicola* (*Metafruticicola*) *pellita* Fér., *Eobania vermiculata* Müll., *Levantina spiriplana* var. *carinata* Bgt., *Helix* (*Cantareus*) *aperta* Born, *Helicella* (*Xerocrassa*) *cretica* Fér. Let., *Rumina decollata gracilis* Pfr. Let., *Ena (Mastus) turgida* Parr., *Clausilia* (*Albinaria*) *brevicollis* Pfr., *Clausilia* (*Albinaria*) *unicolor* Bttg. Let., *Clausilia* (*Albinaria*) *extensa* Pfr.

Other two faunistic and taxonomic works on land and freshwater mollusks of Aegean Islands were those of Fuchs & Käufel (1934, 1936) based on the material collected by Franz Werner in the year 1932. In these works special emphasis was reserved to the genital morphology and geographical distribution of species.

Fuchs & Käufel (1934) reported for Chalki Island only two species: *Helicella* (*Xerocrassa*) *cretica-cauta* Westerlund, and *Metafruticicola* (*M.*) *pellita-graphicotera* Bourguignat. Fuchs & Käufel (1936) report other three species *Mastus* (*M.*) *pupa turgidus*, *Albinaria* (*Albinaria*) *brevicollis chalcidensis* and *Retinella* (*Eopolita*) *protensa protensa*.

Frank (1997) in his work on land mollusks of Rhodes recorded *Xerocrassa cretica* (A. Férussac, 1821) and *Metafruticicola* (*M.*) *pellita* (A. Férussac, 1819) on Chalki and *Levantina spiriplana malziana* (L. Pfeiffer, 1861) on Alimia and Chalki.

Other data on land mollusks of Chalki and Alimia were published in papers concerning a single genus or species: Pfeiffer (1949) on *Levantina* Kobelt, 1871; Zilch (1977) and Nordsieck (2007) on *Albinaria*; Gittenberger & Hausdorf (2004) on *Orculella* Steenberg, 1925; Bank et al. (2013) on *Metafruticicola* Ihering, 1892; Neubert (2014) on *Helix* Linnaeus, 1758.

Until recently a total of 14 species was reported from Chalki and 2 from Alimia. In this paper we present the results of a land snail survey of Chalki and Alimia carried out in July-August 2014 and April 2015 by M. Grano and C. Cattaneo.

MATERIAL AND METHODS

Study area

The Dodecanese Archipelago is a group of 12 large islands plus 150 islets. The island of Chalki is located 13 km west of the island of Rhodes (Fig. 1), its approximate geographical coordinates are: latitude 36°13’51”N, longitude 27°34’35”E. It has an area of 28 square km and its maximum height is Maistros (593 m a.s.l.).

The most interesting aspect of the island is given by vertical cliffs of massive limestone and deep gorges along the coastline (Fig. 3). These vertical cliffs allowed the presence of a rare and highly specialized chasmophytic flora. Several species are endemic with a distribution area limited to the island and to the SE Aegean, including W Turkey (Cattaneo & Grano, 2015a, b). Recently was discovered a new species for science that seems to be restricted to Chalki and the nearby island of Tilos: *Seseli halkensis* Cattaneo, Tan et Biel (Cattaneo et al., 2016). Chalki is mostly constituted by rocky hills characterized almost exclusively by a phryganic vegetation with prevalence of chamaephytes and nano-phanerophytes, as *Sarcopoterium spinosum* (L.) Spach, *Salvia fruticosa* Mill., *Origanum onites* L., *Thymbra capitata* (L.) Cav., *Teucrium capitatum* L. A steppic vegetation is also present on exploited lands and the most representative species are *Hyparrhenia hirta* (L.) Stapf), *Andropogon distachyos* L., *Carlina corymbosa* L., *Picnomon acarna* (L.) Cass., *Echinops spinosissimum* Turra, *Asphodelus fistulosus* L. and *A. ramosus* L. On the hilly slopes of the valleys of Kania, Zies, Pondamos and Ghiali a characteristic floristic composition with *Anagyris foetida* L., *Euphorbia dendroides* L. and *E. characias* L. is developed. The site of Limenari (northwest of Chalki) is characterized by a low maquis whose distinctive elements are *Juniperus phoenicea* L. and *Pistacia lentiscus* L. The tree vegetation is almost exclusively represented by *Olea europaea* L. and *Pistacia terebinthus* L. subsp. *palestina* (Boiss.) Engl., the latter restricted to Pondamos and Ghiali bay. *Pinus brutia* Ten. grows in a small area near Kania. In Chalki there are also several alien species like *Anagyris foetida* (widespread), *Agave americana* L., *Carpobrotus edulis* (L.) N.E. Br, *Opuntia ficus-indica* (L.) Mill. and *Oxalis pes-caprae* L. (Cattaneo & Grano, 2015a, b).

The study area belongs to the Thermo-Mediterranean zone, with a long dry period from end of April to early October.

Alimia is an uninhabited islet located 6 km east of Chalki (Fig. 1). It has an area of 7.42 square km and a maximum height of 274 m a.s.l. Its approximated geographical coordinates are: latitude 36°16'26"N, longitude 27°42'24"E. It consists of limestone rock with steep cliffs on the northern side, lacks superficial hydrography; there's only a small retrodunal pond of brackish water in the bay of Aghios Georgios.

The islet vegetation is characterized by wide low shrubs with *Juniperus phoenicea* and *Pistacia lentiscus* (Fig. 2). Where shrubs become more thin and open, thrives a phrygana almost exclusively characterized by *Thymbra capitata*, to which sometimes is associated *Teucrium capitatum* and more sporadically *Salvia fruticosa*, *Origanum onites* and *Sarcopoterium spinosum*. Clusters of *Pinus brutia* are scarce and localized.

Alimia together with Chalki and the surrounding small islands, is included in the European Network "Natura 2000" as SPA, Special Protection Area, with GR4210026 code.

Sampling methods

The samples examined for this paper were collected by M. Grano and C. Cattaneo, from 30th July to 12th August 2014 and 23rd April 2015. The names of local places mentioned in the text and in the map (Fig. 1) follow the map of Chalki produced by Anavasi Ed. (2008). Specimens were collected chronologically from the following localities:

Chalki, Imborios, 36°13'23"N -27°36'45"E, 22 m a.s.l., 30.VII.2014
Chalki, Kania, 36°14'02"N - 27°37'05"E, 48 m a.s.l., 31.VIII.2014
Chalki, Chorio, 36°13'13"N - 27°35'07"E, 268 m a.s.l., 01.VIII.2014

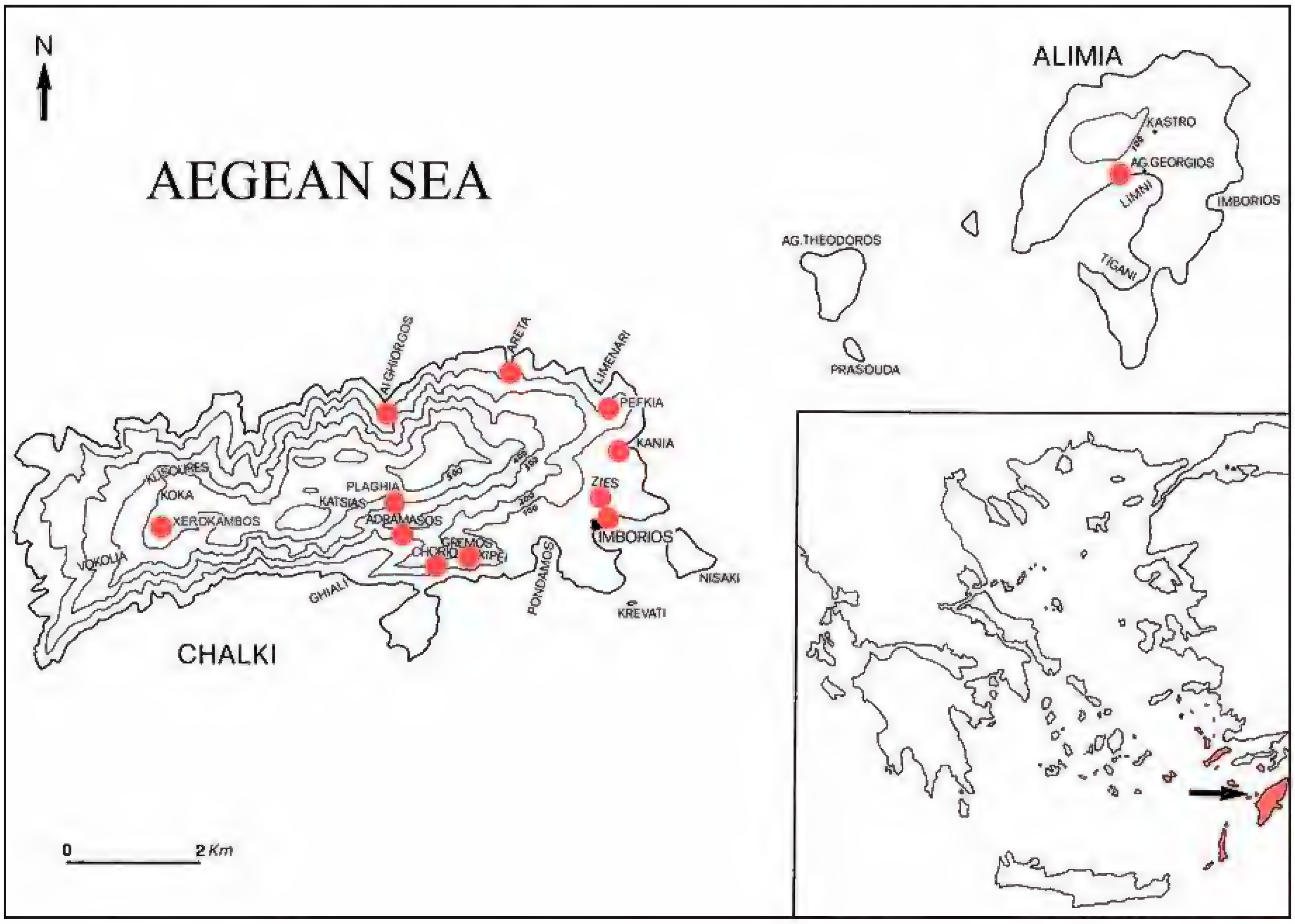
N
AEGEAN SEA
ALIMIA
KASTRO
AG.GEORGIOS
LIMNI
IMBORIOS
TIGANI
AG.THEODOROS
PRASOUDA
AIGHIORGOS
ARETA
LIMENARI
PEFKIA
KANIA
ZIES
IMBORIOS
NISAKI
KREVATI
PONDAMOS
GREMOS
XIPEI
CHORIO
ADRAMASOS
PLAGHIA
KATSIAS
KISOURES
KOKA
XEROKAMBOS
VOKOLIA
GHIALI
CHALKI
0
2 Km

Figure 1. Map of Chalki Island and Alimia Islet.

Chalki, Pefkia, 36°14’15”N - 27°36’53”E, 125 m a.s.l., 02.VIII.2014
Chalki, Ag. Ghiorgos, 36°14’21”N-27°34’43”E, 108 m a.s.l., 03.VIII.2014
Chalki, Plaghia, 36°13’38”N- 27°34’45”E, 423 m a.s.l., 03.VIII.2014
Chalki, Areta, 36°14’43”N-27°35’58”E, 95 m a.s.l., 04.VIII.2014
Chalki, Zies, 36°13’39”N-27°36’57”E, 54 m a.s.l., 05.VIII.2014
Chalki, Xipei, 36°13’11”N-27°35’37”E, 153 m a.s.l., 06.VIII.2014
Chalki, Xerokambos, 36°13’23”N-27°32’30”E, 401 m a.s.l., 07.VIII.2014
Chalki, Adramasos, 36°13’32”N-27°34’48”E, 32 m a.s.l., 12.VIII.2014
Alimia, 36°16’5”N-27°42’12”E, 31 m a.s.l., 09.VIII.2014
Alimia, 36°16’5”N-27°42’12”E, 31 m a.s.l., 12.VIII.2014

The land snails were collected by hand on the soil and under the rocks. Dry shells have been studied as regards size, colour, morphology, sculpture, aperture, plicae and lamellae, lunella and clausilium. Photographs were taken with a digital camera. The living snails were bred from September 2014 to March 2015. In the laboratory they were normally kept in plastic boxes containing damp tissue paper, lettuce or carrot. The contents were changed twice a week. In order to study and illustrate genital organs, the specimens were drowned in water and fixed in 75% ethanol. Reproductive apparatus was extracted by means of scalpel, scissors and needles. Height and maximum diameter of the shell along with some parts of genitalia were measured (in millimeters) with a digital gauge. Identification of the slug species was based on the photos, since no live slugs were sampled. All the shell lots and anatomical preparations are kept in the collection of the first author. Taxonomical references are based on the checklist of the land and freshwater Gastropoda of Greece (Bank, 2011).

ABBREVIATIONS AND ACRONYMS. D = diameter; H = height; moll. = mollusk; End = Endemic: species exclusive of Chalki Island; Dod = Dodecanese: species distributed only on the Dodecanese Islands; Aeg = Aegean: species which are also present on other Aegean islands or/and nearby coastal mainland areas of Greece and Turkey; Grek = Greek: species distributed within the Greek mainland or/and islands; E Med = East Mediterranean: species which are found in the eastern part of Mediterranean region; Med = Mediterranean: species which are found around the Mediterranean; Eur = European: species found in various countries of Europe.
Anatomical acronyms: AG = albumen gland, AR = appendicular retractor muscle, BC = bursa copulatrix, BCD = diverticulum of bursa copulatrix, CD = copulatory duct, DBC = duct of bursa copulatrix, DE = distal epiphallus, E = epiphallus, F = flagellum, FO = free oviduct, G = penial papilla, GA = genital atrium, HD = hermaphrodite duct, O = ovotestis, OV = ovispermiduct, P = penis, PA = penial appendix, PC = penial caecum, PD = penial diverticulum, PDP = penial diverticulum pleat, PE = proximal epiphallus, PR = penial retractor muscle, T = talon, V = vagina, VD = vas deferens, VP = V-shaped pleat. Conchological acronyms: CL = columellar lamella, L = lunella, LPP = lower palatal plica (basal plica), PL = parietal lamella, PP = principal plica, PUPP = posterior upper palatal plica, SCL = subcolumellar lamella, SL = spiral lamella.

RESULTS

The catalog lists the bibliographical references, including incorrect determinations; notes on distribution, biology, morphology and taxonomy are also given.

SYSTEMATICS

Phylum MOLLUSCA Cuvier, 1795
Classis GASTROPODA Cuvier, 1795
Infraclassis PULMONATA Cuvier in Blainville, 1814
Ordo STYLOMMATOPHORA A. Schmidt, 1855
Familia ORCULIDAE Pilsbry, 1918
Genus *Orculella* Steenberg, 1983

Orculella critica (L. Pfeiffer, 1856)

Pupa (*Orcula*) *scyphus* - Von Martens, 1889: 200 - Chalki

Orculella critica - Gittenberger & Hausdorf, 2004: 119–120 - Chalki islet

DISTRIBUTION AND BIOLOGY. Greek and Aegean distribution, reported by Hausdorf (1996) also for two west coast localities in Turkey. *Orculella critica* occurs in plant litter at the base of stones and rocks in rocky limestone habitats.

REMARKS. *Orculella critica* was reported by Von Martens (1889, sub *O. scypus*) and Gittenberger & Hausdorf (2004) on Chalki Island, while we were unable to find specimens and shells. The populations of Chalki are characterized by comparatively large, especially broad, shells (height 6.2–7.6 mm; width 2.6–2.9 mm) than those from Peloponnese, with a parietalis still high at the ventral side, a prominent subangularis and a columellaris very high in left lateral position inside the body-whorl (Gittenberger & Hausdorf, 2004).

Familia PLEURODISCIDAE Wenz, 1923
Genus *Pleurodiscus* Wenz, 1923

Pleurodiscus balmei (Potiez et Michaud, 1835)

EXAMINED MATERIAL. Chalki, Chorio, 01.VIII.2014, 36°13'13"N-27°35'07"E, 268 m a.s.l., 1 shell.

DISTRIBUTION AND BIOLOGY. Species with fragmentary East Mediterranean distribution, perhaps, partly due to passive dispersal. This xeroresistant species inhabits open environments, but it is frequent also in ruderal habitats.

REMARKS. *Pleurodiscus balmei* is known for Rhodes (Paget, 1976; Maassen, 1981) and we have found a shell on Chalki, among the ruins of the uninhabited houses of Chorio (Fig. 5).

Familia ENIDAE B.B. Woodward, 1903 (1880)
Genus *Mastus* Beck, 1837

Mastus emarginatus turgidus (Kobelt, 1877)

Bulimus (*Mastus*) *carneolus* - Von Martens, 1889: 199 - Chalki
Mastus (*Mastus*) *pupa turgidus* - Fuchs & Käufel, 1936: 561 - Charki

EXAMINED MATERIAL. Alimia, 09.VIII.2014, 36°16'5"N-27°42'12"E, 31 a.s.l., 1 shell.

DISTRIBUTION AND BIOLOGY. Endemic species of the southern islands of the Dodecanese: Rhodes, Chalki, Karpathos, Saria, Kasos, Armathia (Fuks & Käufel, 1936; Gambetta, 1929). It occurs in open shrubland habitats, under stones.

REMARKS. We have sampled only a shell on the islet of Alimia (Fig. 6). *Mastus turgidus* is a species recognizable for its small shell with globular aspect, mouth square-shaped with reflexed peristome, weak parietal callus and a tubercle in the upper, right corner.

Mastus sp.

EXAMINED MATERIAL. Chalki, Xerokambos, 07.VIII.2014, 36°13'23"N-27°32'30"E, 401 a.s.l., 2 shells.

REMARKS. Two shells of a second species of *Mastus* were sampled by us at Xerokambos, Chalki (Fig. 7). They are elongate-ovoid, with a spire of 7 whorls, apical whorls convex, the lower ones more flattened; the surface is covered with irregular fine growth lines; sutures shallow; umbilicus open, small; thick palatal callus; a conspicuous angular denticle present; peristome slightly reflected. Dimensions: height 14.7 and 16.6 mm, diameter 6.5 and 6.6 mm.

It is similar to *M. cretesis* (L. Pfeiffer, 1846) from the island of Crete, having slender shell, with 7 whorls and irregular growth lines, but a definitive specific identification is impossible, due to the lack of specimens for genital dissection.

Genus *Rhabdoena* Kobelt et Möllendorff, 1902

Rhabdoena cosensis (Reeve, 1849)

Zebrina (*Rhabdoena*) *cosensis* (Reeve, 1849) - Bank & Menkhorst, 1992: 127–133, Fig. 37 - Insel Chalchi

EXAMINED MATERIAL. Chalki, Chorio, 01.VIII.2014, 36°13'13"N-27°35'07"E, 268 a.s.l., 1 moll., 1 shell.

DISTRIBUTION AND BIOLOGY. Aegean distribution: West Turkey and East Aegean Islands from Lésvos to Rhodes. *Rhabdoena cosensis* occurs on shaded, limestone walls with low vegetation. It seems to be obligate rock dwellers snail.

REMARKS. The shells (Fig. 8) and the examined genital apparatus correspond fairly well to the description and drawings of Bank & Menkhorst (1992). The genitalia show only one retractor, which inserts in the branching point of the appendix from the penis, the caecum rises from the central part of the epiphallus and the central part of the penial appendix is relatively short (Fig. 9). The examination of the inner structure of the penis shows the walls with very low folds and a very short and slightly conical penial papilla (Fig. 10).

Genus *Zebrina* Held, 1837

Zebrina fasciolata (Olivier, 1801)

EXAMINED MATERIAL. Chalki, Kania, 31.VIII.2014, 36°14'02"N-27°37'05"E, 48 a.s.l., 4 moll.

DESCRIPTION. Shell (Figs. 11, 12) dextral, ovoidal-oblong; spire with 7 slightly convex whorls; sutures shallow; umbilicus closed; blunt apex, white-yellowish in colour; teleoconch white or white yellowish, with longitudinal brown bands (one specimen without bands), on external surface microsculpture of fine longitudinal lines which disappear at the intersection with spiral lines; aperture oblique, semi-ovate with brown palatus; peristome interrupted, whitish, basal and palatal margin not or just reflected. Dimensions: height 18.4 mm (15.8–24.2), diameter 8.1 mm (6.3–12.7).

Genitalia (Figs. 13–17) (four specimens examined), characterized by: short vagina (2.27 mm); slightly longer copulatory duct (2.64 mm), ending in a branched bursa copulatrix complex: one branch consists of a long diverticulum of bursa copulatrix (7.2 mm), the other of a thin duct of the bursa copulatrix (2.55 mm) and oval bursa copulatrix (1.6 mm); penial complex consists of penis, penial appendix, epiphallus, and flagellum; penis cylindrical (2.8 mm); the penial appendix very long, it branches off from the proximal end of the penis and consists of three sections: first section short (2 mm), wide, cylindrical with a slightly constriction in its distal end; second section (1.9 mm) thinner, it widens slightly in its distal end; third section very long (7.7 mm), slender, slightly wider in its distal end; epiphallus cylindrical (3.83 mm), in its apex there are a rounded penial caecum and a short, conical flagellum; vas deferens enters laterally on the apex of epiphallus; there are two retractor muscles: a penial retractor and an appendicular-retractor, which join shortly before the attach to the diaphragm. Spermatophore (Fig. 16) glossy, golden, with conical and amply curved anterior portion, central portion regularly tubular, posterior portion double S-shaped with a hook and some spiral ridges, posterior apex conical. The spermatophore was found with the anterior portion inside the diverticulum of the bursa copulatrix, the hook at the branch of the duct of the bursa copulatrix and the posterior portion inside the copulatory duct.

DISTRIBUTION AND BIOLOGY. *Zebrina fasciolata* has NE-Mediterranean chorotype and it is widespread from Greece (Rhodes, Megalo Zafrano), Cyprus, S-Turkey (from Izmir eastwards) to Syria and Palestine. This species lives usually in dry shrublands, and it is met under stones.

REMARKS. In this paper, we report for the first time the presence of *Zebrina* on Chalki Island and this allowed us to make some taxonomic observations. *Zebrina fasciolata* varies in shape, size and coloration of the shell and are known different taxonomic interpretations also for the structure of the genitalia. The genital apparatus was studied by Gambetta (1929, 96–98, figs. 21) after specimens from Rhodes, Hesse (1933, 183–185, figs. 22 A, D) after specimens from Rhodes and Aleppo, Fuchs & Käufel (1936, 573–576, figs. 13–15) after specimens from Rhodes and Tartus, Maassen (1981, 28, Pl. 14, fig. 61) and Bank & Menkhorst (1992, 122–126, figs. 30, 31, 34, 35) after specimens from Rhodes. From their descriptions *Z. fasciolata* from Rhodes includes two well characterized forms. In the typical form the penial appendix branches off from the proximal end of the penis; there are two retractor muscles: a penial retractor and an appendicular-retractor, which join shortly before the attach to the diaphragm. In the second form the appendix stems from the distal end of the penis; there is only the penial-retractor and the proximal part of the appendix is very short.

Gambetta (1929) was the first author to identify the second form as a distinct taxon and she names it *Z. fasciolata candida* (L. Pfeiffer, 1848), although the description and the illustration are unclear. Hesse (1933) and Fuchs & Käufel (1936) note that the variation in the reproductive system of the two forms is not related to the variation in shell pattern and all others the above-mentioned authors consider *fasciolata* a species with extremely variable genitalia structure (see also Heller, 1976; Maassen, 1981). However Paget (1976) considered *candida* a valid subspecies.

Four of the five specimens of *Zebrina* we had the opportunity to examine, belong to the typical *Z. fasciolata*, the fifth one, without bands on the shell, with the genital structure like that of *candida*. We have examined for the first time the internal structure of the penis and epiphallus. Both forms have the inner walls of the penis covered with large papillae and those of epiphallus with small papillae, plus some short folds originating from the apex of epiphallus (Figs. 14, 17, 21). However, *Z. fasciolata* has at the point of transition from epiphallus into the penis a conical penial papilla covered with very small tubercles (Figs. 14, 17), while our specimen of *Z. candida* has no penial papilla (Fig. 21).

Despite the few specimens observed, these new data, combined with the already known literature and the presence of two different sympatric populations in the same locality allow us to consider *Z. fasciolata* and *Z. candida* two distinct species.

Zebrina candida (Westerlund, 1887)

Examined material. Chalki, Kania, 31.VIII.2014, 36°14’02”N-27°37’05”E, 48 m a.s.l., 1 moll.

Description. Shell (Fig. 18) very similar to that of the previous species, but white in colour, without bands.

Genitalia (Figs. 19, 21) (Gambetta (1929, 96–98), Hesse (1933, 183–185, figs. 22 B, C), Fuchs & Käufel (1936, 573–576, figs. 16, 17), Maassen (1981, 28, Pl. 14, fig. 62), Bank & Menkhorst (1992, 122–126, figs. 32, 33), characterized by: a penial appendix which stems from the distal end of the penis; the proximal part of the appendix very short (0.47 mm) and only a penial-retractor (appendicular retractor absent); penial papilla absent.

Spermatophore (Fig. 20) very similar to that of the previous species, only slightly smaller.

Distribution and Biology. At present *Z. candida* is known from Rhodes Island and Chalki Island, where it lives in sympatry with *Z. fasciolata.*

Remarks. Many names were published by past authors for *Z. fasciolata*: *Bulimus fasciolatus* var. *maior* Charpentier, 1847, locus typicus “*In Syrein, zumal zwischen Latakieh und Tripolis*”; *Bulimus hebraicus* L. Pfeiffer, 1854, without locus typicus, later used by Forcart (1940) for populations of *Z. fasciolata* of Turkey; *Bulimus fasciolatus* var. *piochardi* Heynemann, 1870; locus typicus “*Cypern*” [= Cyprus]; *Bulimus calverti* Bourguignat, 1876, locus typicus “*Ile de Rhodes*”; *Bulimus fasciolatus* forma *gracilis* Westerlund, 1887, locus typicus: Insel Rhodos (see Bank & Menkhorst, 1992); *Bulimus fasciolatus* forma *candidus* Westerlund, 1887, without locus typicus.

Gambetta (1929) was the first author to attribute the name *candida* Pfeiffer, 1848 to a *Zebrina* from Rhodes with white shell, characterized by a structure of the genitalia different from that of the typical *Z. fasciolata*. Subsequent authors have always used the name *candida* in the sense attributed by Gambetta (1929), both those who considered it a valid species (Paget, 1976) and the authors who have considered *candida* a synonym of *fasciolata* (Hesse, 1933; Fuchs & Käufel, 1936; Maassen, 1981; Bank & Menkhorst, 1992; Heller, 1976).

However it must be specified that Pfeiffer (1848) did not published a valid description of *candida*, since he used the word “candidus” as an adjective in the description of a variety “*ß unicolor candidus*”. Westerlund (1887) was the first author to publish a valid description of candida: “*candidus Pfr., Einfarben weiss*”. From the context of the work of Westerlund (1887) it is also clear that the name hasn’t infrasubspecific rank, because the author uses the word “form” (Art. 45.6.4. ICZN,1999).

Familia SUBULINIDAE P. Fischer & Crosse, 1877
Subfamilia RUMININAE Wenz, 1923
Genus *Rumina* Risso, 1826

Rumina cf. ***saharica*** Pallary, 1901

Rumina decollata gracilis - Gambetta, 1929: 94 - Calchi

Examined material. Alimia, 12.VIII.2014, 36°16’5”N-27°42’12”E, 31 m a.s.l., 3 shells.

Chalki, Kania, 31.VIII.2014, 36°14’02”N-27°37’05”E, 48 m a.s.l., 1 shell.

Distribution and Biology. East Mediterranean distribution. It often occurs in dry and open habitats under stones or hidden in the soil, but also in shady habitats between plants and plant debris, and cultivated areas.

REMARKS. *Rumina saharica* is characterized by a shell decollate (in adult specimens), slender, subcylindrical (Fig. 22); animal whitish; genitalia with vagina internally decorated with longitudinal, not crenulate pleats (crenulate pleats in *R. decollata*) and penis internally with some sparsely distributed papillae towards the proximal end (abundant, prominent papillae in *R. decollata*). Prévot et al. (2013) based on a phylogenetic study of mtDNA and ITS sequence data, support the species level status of *R. saharica* and suggest that at least six clades in *R. decollata* s.l. are putative species: the dark (clade A) and light (clade E) color phenotypes from France and Spain, three North African species (clades B, C and D), and an Italian-Croatian species (Clade F). These putative species need further corroboration by an integrative taxonomic approach, combined with a more comprehensive geographic sampling. Clades A and E are also present in northern Africa, so this region shows a high degree of genetic and also morphological differentiation (Bourguignat, 1864).

Prévot et al. (2013) use the name "*saharica*" for the species widespread in the Eastern Mediterranean, but "*saharica*" was described by Pallary (1901) for populations form Algeria (locus typicus: *Dans les alluvions del'oued Keroua, près d'El Abiod Sidi cheikh et del'oued Sefra. Dans celles de l'oued Djelfa et del'O. Seguen*), therefore further molecular and morphological analysis are necessary to ascertain the conspecificity of the populations from eastern mediterranean region with the topotypical *R. saharica* from Algeria. For these reasons we prefer to name the *Rumina* from Chalki and Alimia *R.* cf. *saharica*.

Familia CLAUSILIIDAE J.E. Gray, 1855
Subfamilia ALOPIINAE A.J. Wagner, 1913
Tribus MEDORINII H. Nordsieck, 1997
Genus *Albinaria* Vest, 1867
Subgenus *Albinaria* Vest, 1867

Albinaria* (*Albinaria*) *brevicollis chalcidensis (O. Boettger, 1889)

Clausilia (*Albinaria*) *brevicollis* - Von Martens, 1889: 200 - Chalki

Clausilia brevicollis var. *chalcidensis* - O. Boettger, 1889: 38 - insel Chalki

Clausilia brevicollis var. *chalcidensis* - Westerlund, 1890: 61 - ins. Chalki

Clausilia brevicollis var. *chalcidensis* - Westerlund, 1901: 43 - I. Chalki

Albinaria (*Albinaria*) *brevicollis chalcidensis* - Fuchs & Käufel, 1936: 591 - Charki

Albinaria (*Albinaria*) *brevicollis chalcidensis* - K.L. Pfeiffer, 1955: 127-128, Pl 9, fig. 16 - Chalchi an dem aus Kreidekalkfels

Albinaria brevicollis chalcidensis - Zilch, 1977: 326 - Insel Calchi

Albinaria brevicollis chalcidensis - Nordsieck, 2007: 45

EXAMINED MATERIAL. Chalki, Chorio, 01.VIII.2014, 36°13'13"N-27°35'07"E, 268 m a.s.l., 14 shells, 5 moll.; Chalki, Ag. Ghiorgos, 03.VIII.2014, 36°14'21"N-27°34'43"E, 108 m a.s.l., 8 shells; Chalki, Plaghia, 03.VIII.2014, 36°13'38"N-27°34'45"E, 423 m a.s.l., 3 moll., 8 shells; Chalki, Areta, 04.VIII.2014, 36°14'43"N-27°35'58"E, 95 m a.s.l., 3 moll., 11 shells; Chalki, Imborios, 30.VII.2014, 36°13'23"N-27°36'45"E, 22 m a.s.l., 2 shells; Chalki, Xerokambos, 07.VIII.2014, 36°13'23"N-27°32'30"E, 401 m a.s.l., 8 shells; Chalki, Pefkia, 02.VIII.2014, 36°14'15"N-27°36'53"E, 125 m a.s.l., 6 shells.

Type series. Lectotypus SMF 58307; Paratypes: SMF 58308/4, 58309/4 Slg. Moellendorff, 58310/6 Slf. Naegel, 93464/5 Slf. O. Boettger.

Type locality. Greece: Chalki Islands, west of Rhodes Island.

DESCRIPTION. Shell (Figs. 23, 24) sinistral, fusiform, slender; spire with 10–11.5 whorls, last whorl tapering downwards; apex usually black, the others whorls white-bluish with dark spots; sutures moderately deep; umbilicus closed; apical whorls (1.5) smooth, the following striated or smooth, last whorl ribbed, but in its first half the ribs start from the base and do not reach the suture, then gradually lengthen until reaching the suture; cervix with short basal and dorsal keels, dorsal as high as basal keel or slightly higher; aperture oval, inside brown-orange, peristome continous, detached, thickened, slightly reflected. Inside aperture there are 3 plicae and lunella (on palatum) and 4 lamellae (on parietum and columellar side). On palatum starting from suture there are: a long and raised principal plica, slightly wider in its posterior portion; short posterior upper palatal plica fused to lunella apex; lunella dorsolateral, wider to its base; a rudiment basal plica present and fused to the base of lunella (Figs. 25, 26). On parietum starting from suture there are: non emerged spiral lamella in the centre of parietum, more raised in its posterior portion; (upper) parietal lamella reaching spiral lamella; low columellar lamella; non emergent subcolumellar lamella (Figs. 27, 28). Clausilium plugh-like, basal plate entire, subrectangular, sutural angle slightly bent up (Figs. 29, 30). Dimensions (16 shells measured): height 16.2 mm (14–18.1), diameter 3.83 mm (3.7–4.07).

Body. Animal narrow, posteriorly pointed, white grayish in color with darker tubercles, sole white grayish.

Genitalia. (Fig. 31) (4 specimens examined) are characterized by: variably long vagina (2–4.1 mm); short free oviduct and copulatory duct (1.6 mm), the last ending in a branched bursa copulatrix complex: one branch consists of a long diverticulum of bursa copulatrix (4.4 mm), the other of a very short duct of bursa copulatrix (1.3 mm) and oval bursa copulatrix. Penial complex consists of epiphallus, penial diverticulum and penis; epiphallus (3.4 mm) divided, by point insertion of penial retractor muscle, into proximal portion and very short distal portion; penis cylindrical (2.4 mm) and wider than epiphallus, large penial diverticulum (long and wide as much as the penis) arising on border between distal epiphallus and penis. Internal walls of penis with a V-shaped pleat; internal walls of penial diverticulum with some longitudinal pleats, one of which surrounds the opening of the epiphallus into the penis (Figs. 32, 33); penial retractor muscle simple, only a specimen has penial retractor divided into two branches shortly before the attachment on epiphallus.

Distribution and Biology. *Albinaria brevicollis chalcidensis* is endemic of Chalki Islands. It lives on rocky limestone outcrops and it is widespread and common all over Chalki.

Remarks. *Albinaria brevicollis* s.l. is spreading in the Dodecanese Islands (Greece) and Resadiye peninsula (Turkey), with sixteen subspecies (Bank, 2011; Nordsieck, 2013). For Chalki Island Boettger (1889) described the subspecies *chalcidensis* based only on exterior shell characters. Westerlund (1890, 1901) redescribes the shell. Fuchs & Käufel (1936) describe and illustrate the genitalia of four subspecies: *brevicollis* (sub *rhodia* Pollonera, 1916), *astropalia* (O. Boettger, 1883), *casia* (O. Boettger, 1883), and *superba* (O. Boettger, 1889) (sub *atavirensis* Pollonera, 1916). They show a substantial uniformity in the genital structure of these subspecies, but also a differentiation in the form of penial diverticulm. Pfeiffer (1955) revises the whole *brevicollis* group and describes the variability of the genitalia of *Albinaria brevicollis unia* (O. Boettger, 1883).

The structure of the genitalia of *Albinaria brevicol-lis chalcidensis* is similar to those of the other subspecies illustrated by Fuchs & Käufel (1936) and by Pfeiffer (1955). *Albinaria brevicollis chalcidensis* appears different for the larger size of the penial diverticulum with cylindrical shape and rounded apex. The subspecies *astropalia*, *casia* and *unio* have a diverticulum significantly smaller, while *Albinaria brevicollis brevicollis* and the subspecies *superba* have the diverticulum proportionately shorter compared to the penis, in addition *Albinaria brevicollis superba* also differs for the pointed tip. Also the recent molecular data of Douris et al. (2007) confirm a substantial genetic differentiation between the *Albinaria* of Chalki and other subspecies of *A. brevicollis*.

Gambetta (1929) reports for Chalki only *Clausilia* (*Albinaria*) *unicolor* Boettger, but this species later has not been confirmed on the island.

Albinaria* (*Albinaria*) *brevicollis superba (O. Boettger, 1889)

Albinaria (*Albinaria*) *brevicollis superba* - K.L. Pfeiffer, 1955: 117–120, Pl. 8, f. 8. - insel Alinnia
Albinaria brevicollis superba - Paget, 1976: 761, 762 - Insel Alinnia

Examined material. Alimia, 09.VIII.2014, 36°16'5"N-27°42'12"E, 31 m a.s.l., 12 shells.

Distribution and Biology. *Albinaria brevicollis superba* is endemic of Rhodes Island and the islet of Alimia. It lives on rocky limestone outcrops.

Remarks. Boettger (1889) describes *C. brevicollis* var. *superba* for Rhodes near Kastello village, characterized by shell larger than typical *brevicollis*, lower lamella more developed and weaker or obsolete ribs on the median whorls. Pfeiffer (1955) examines both the type series of *superba*, and other specimens collected by himself on the Mountain Prophet Elias near Kastello (Rhodes). He considers *superba* a subspecies with larger dimensions, with lower lamella more perpendicular to the edge of the opening, but with variable keel and rib. Pfeiffer (1955) reports *superba* for the first time on the islet of Alinnia (Alimia) with shells entirely ribbed, with dorsal keel and without black spots on the surface. Paget (1976) also considers *superba* a valid subspecies and he proposes the taxon *atavirensis* as synonym.

The shells examined in this study well correspond to Pfeiffer's description in size, ribs, keels, and lamellae (Figs. 34–36). Dimensions (7 shells measured): height 16.2 mm (17.2–14.5), diameter 3.4 mm (3.25–3.65); 11 ribs per 2 mm of the penultimate whorl. Whorls with some dark spots on the surface of shell. Clausilium plugh-like, basal plate entire, subrectangular, with rounded distal edge (Fig. 37).

Pfeiffer (1955) reports a population of *Albinaria brevicollis brevicollis* on the ruins of the small castle of Alimia, but we have not sampled this population.

Subgenus *Mirabellina* O. Boettger, 1878

Albinaria* (*Mirabellina*) *teres nordsiecki Zilch, 1977

Clausilia teres var. *extensa* - O. Boettger, 1889: 46–47 - insel Chalki

Clausilia teres var. *extensa* - Von Martens, 1889: 200 - Chalki

Clausilia teres - Kobelt, 1898: 313 - insel Chalki

Clausilia (*Albinaria*) *teres* var. *extensa* - Gambetta 1929: 101, 113 - Calchi

Albinaria teres nordsiecki - Nordsieck, 2013: 5 - Chalki Island

EXAMINED MATERIAL. Chalki, Zies, near the church Aghias Kiriakis, 05.VIII.2014, 36°13'39''N -27°36'57''E, 54 m a.s.l., 3 shells, 6 moll.

DESCRIPTION. Shell (Figs. 38, 39) sinistral, fusiform, spire with 11 whorls, last whorl tapering downwards, apex black and smooth, the other whorls whitish, ribbed, 6/7 ribs per 2 mm of the penultimate whorl, with fine lines between the ribs; cervix more coarsely ribbed than the upper whorls, basal keel visible, dorsal keel obsolete; umbilicus closed; aperture oval, peristome continous, detached, slightly reflected. Inside aperture there are 2 plicae and lunella (on palatum) and 4 lamellae (on parietum and columellar side). On platum starting from suture there are a long and raised pincipal plica, slightly wider in its posterior portion; short posterior upper palatal plica fused to lunella apex; lunella obsolete in its apical portion, absent in its basal portion (Figs. 40, 41); on parietum starting from suture there are: non emerged spiral lamella in the centre of parietum; (upper) parietal lamella very short and toothlike, low columellar lamella; non emerged subcolumellar lamella (Figs. 42, 43). Clausilium plugh-like, basal plate entire with slightly curved palatal edge (Figs. 44, 45).

Dimensions (7 shells measured): height 17.4 mm (17–18.1), diameter 3.9 mm (3.86–4).

Genitalia (Fig. 46), 3 specimens examined, consisting of large ovotestis with many close acini; long convoluted hermaphrodite duct, entering base of small talon (Fig. 49); large albumen gland; well developed ovispermiduct, copulatory duct and free oviduct of the same lenght (2.4–2.6 mm); copulatory duct ending in a branched bursa copulatrix complex: one branch consists of a long diverticulum of bursa copulatrix (5.7–4.1 mm), the other of a very short copulatrix duct (1.1–1.9 mm) and oval bursa copulatrix (1.2–1.9); medium long vagina (2.6–4 mm). Penial complex consists of epiphallus, penial diverticulum and penis; epiphallus (2.6–3.8 mm) divided, by point insertion of penial retractor muscle, into proximal portion and very short distal portion; penis (2.5–2.85 mm) cylindrical and wider than epiphallus, short and conical penial diverticulum (0.8–1.3 mm), arising on border between distal epiphallus and penis. Internal walls of penis with a V-shaped pleat; internal walls of penial diverticulum with a pleat, which surrounds the opening of the epiphallus into the penis (Figs. 47, 48); in two specimens the penial retractor muscle is divided into two branches shortly before the attachment on epiphallus (Figs. 46–47), in the third specimen it is undivided with large attachment on epiphallus.

DISTRIBUTION AND BIOLOGY. *Albinaria teres nordsiecki* is native of Crete Island, where it is distributed from west of Sitia to south eastern Dikti mountains and east of Ierapetra, with region of Goudouras and Koufonisi Island. It is a rock dwelling snail, usually limestone rocks.

REMARKS. The presence of *A. teres nordsiecki* on Chalki Island only nearby the church of Aghias Kiriakis (Chalki), and nowhere else in the survey area, strongly suggests that it was introduced by man from the island of Crete (O. Boettger, 1889; Nordsieck, 2013).

Familia OXYCHILIDAE P. Hesse 1927 (1879)
Subfamilia OXYCHILINAE P. Hesse, 1927 (1879)
Genus *Eopolita* Pollonera, 1916

Eopolita protensa protensa (A. Férussac, 1832)

Hyalina aequata - Von Martens, 1889: 190 - Chalki
Retinella aequata - Gude, 1902: 124 - Kharki (Chalki)
Retinella (*Eopolita*) *protensa protensa* - Fuchs & Käufel, 1936: 614 - Charki

EXAMINED MATERIAL. Chalki, Chorio, 01.VIII.2014, 36°13'13"N-27°35'07"E, 268 m a.s.l., 3 shells.

DISTRIBUTION AND BIOLOGY. *Eopolita protensa* has an East Mediterranean distribution, from Aegean region to South-East Turkey, North-West Syria, Lebanon, Israel, Jordan, Libya and Cyprus. It lives under stones and in rock crevices. *Eopolita protensa* is a carnivorous snail, and feeds on earth worms and snails.

Familia MILACIDAE Ellis, 1926
Genus *Tandonia* Lessona et Pollonera, 1882

Tandonia cf. ***pageti*** (Forcart, 1972)

EXAMINED MATERIAL. Chalki, Chorio, 23.IV.2015, 36°13'13"N, 27°35'07"E, 268 m a.s.l.

DISTRIBUTION AND BIOLOGY. *Tandonia pageti* is known from Rhodes Island and SW Turkey.

REMARKS. In external appearance it resembles a limacide for the large dimensions, the poorly arched short keel and small skin sculpture. Through the photos the color appears brownish gray with dense small yellow and brown spots.

Only two photos, and size (length approximately 8 cm) were taken of this mollusk (Fig. 50). Further researches are needed for a definitive specific identification of *T. pageti* and the following species *D.* cf. *samium* on the island of Chalki.

Familia AGRIOLIMACIDAE H. Wagner, 1935
Subfamilia AGRIOLIMACINAE H. Wagner, 1935
Genus *Deroceras* Rafinesque, 1820
Subgenus *Deroceras* Rafinesque, 1820

Deroceras (***Deroceras***) cf. ***samium*** Rähle, 1983

EXAMINED MATERIAL. Chalki, Imborios, 23.IV.2015, 36°13'23"N-27°36'45"E. 22 m a.s.l..

REMARKS. For this slug, as for the previous species, were taken by us just a picture (Fig. 51) and the dimensions. The dark-gray color and the size (length approximately 40 mm) allow us to tentatively classify this slug as *D.* cf. *samium*, a species with wide distribution in the Dodecanese.

Familia COCHLICELLIDAE Schileyko, 1972
Genus *Cochlicella* A. Férussac, 1821
Subgenus *Cochlicella* A. Férussac, 1821

Cochlicella* (*Cochlicella*) *acuta (O.F. Müller, 1774)

EXAMINED MATERIAL. Chalki, Imborios, 30.VII.2014, 36°13'23"N-27°36'45"E. 22 m a.s.l., 13 shells.

DISTRIBUTION AND BIOLOGY. This Holomediterranean-Atlantic species lives on retro dune habitats and internal drier biotopes. It is a very common species, which often occurs in large aggregations on plants and in crevices of trees. Our specimens were found on the walls of old abandoned houses in Imborios.

REMARKS. The population of Chalki has small dimensions like those of Rhodes (Frank, 1997): H: 9.1 mm, D: 4 mm (Fig. 52).

Familia HYGROMIIDAE Tryon, 1866
Subfamilia GEOMITRINAE C. Boettger, 1909
Tribus TROCHOIDEINI H. NORDSIECK, 1987
Genus *Xerocrassa* Monterosato, 1892
Subgenus *Xerocrassa* Monterosato, 1892

Xerocrassa* (*Xerocrassa*) *cretica (L. Pfeiffer, 1841)

Helix (*Xerophila*) *cretica* - Von Martens, 1889: 196 - Insel Chalki
Helicella (*Heliomanes*) *cretica* - Gude, 1902: 124 - Kharki (Chalki)
Helicella (*Xerocrassa*) *cretica* - Gambetta, 1929: 92 - isola di Calchi
Helicella (*Xerocrassa*) *cretica cauta* - Fuchs & Käufel, 1934: 84 - Chalki

EXAMINED MATERIAL. Chalki, Xipei, 06.VIII.2014, 36°13'11"N-27°35'37"E, 153 m a.s.l., 16 moll. juv.; Alimia, on limestone, 12.VIII.2014, 36°16'5"N-27°42'12"E, 31 m a.s.l., 4 shells.

DISTRIBUTION AND BIOLOGY. Species with East Mediterannean distribution: East Greece, Aegean Islands, West coast of Asia Minor, Cyprus, African coast from Egypt to Libya. It lives in every kind of habitats, from beaches to high mountains, but mainly on dry vegetation in coastal habitats.

REMARKS. A common species on Chalki Island.

Subgenus *Xeroclausa* Monterosato, 1892

Xerocrassa* (*Xeroclausa*) *meda (Porro, 1840)

EXAMINED MATERIAL. Chalki, Ag. Ghiorgos, 03.VIII.2014, 36°14'21"N-27°34'43"E, 108 m a.s.l., 2 shells.

DISTRIBUTION AND BIOLOGY. It is known for Malta, Sicily, southern Italy, Sardinia (Sassari) and Aegean Islands: Kos and Lesvos. It is common in anthropogenic habitat: gardens, on walls, under stones. These habitats suggest passive introduction by man.

REMARKS. Perhaps a native species of Sicily and Malta, where it lives in seminatural habitats, and probably introduced in southern Italy, Sardegna (Sassari) and Aegean Islands: Kos, Lesvos (Hausdorf & Sauer, 2009). In Chalki only two fresh death shells were sampled in seminatural habitats on the north side of the island (Fig. 53).

Subfamilia HYGROMIINAE Tryon, 1866
Tribus HYGROMIINI Tryon, 1866
Genus *Metafruticicola* Ihering, 1892

Metafruticicola* (*Metafruticicola*) *pellitus pellitus (A. Férussac, 1832)

Helix (*Pseudocampylaea*) *pellita* - Von Martens, 1889: 194 - insel Chalki
Hygromia (*Metafruticicola*) *pellita* - Gude, 1902: 124 - Kharki (Chalki)
Metafruticicola (*Metafruticicola*) *pellita graphicotera* - Fuchs & Käufel, 1934: 87 - Chalki
Metafruticicola (*Metafruticicola*) *pellita* - Bank et al., 2013: 70–76 - Island Chalki, surroundings Chorion; monastery Agios Johannis NW Chalki town.

EXAMINED MATERIAL. Chalki, Ag. Ghiorgos, 03.VIII.2014, 36°14'21"N-27°34'43"E. 108 m a.s.l., 1 shell.

DISTRIBUTION AND BIOLOGY. Aegean Distribution: East Crete, Cyclades, Dodecanese, Northern Sporades, Limnos and the Turkish Island of Gökceada (Bank et al., 2013).

Metafruticicola pellitus lives in limestone habitats.

Familia HELICIDAE Rafinesque, 1815
Subfamilia HELICINAE Rafinesque, 1815
Tribus HELICINI Rafinesque, 1815
Genus *Levantina* Kobelt, 1871
Subgenus *Levantina* Kobelt, 1871

Levantina* (*Levantina*) *spiriplana malziana (L. Pfeiffer, 1861)

Helix (*Iberus*) *spiriplana* - Von Martens, 1889: 195 - insel Chalki
Helix (*Levantina*) *spiriplata* - Gude, 1902: 124 - Kharki (Chalki)
Levantina (*Levantina*) *spiriplana* var. *carinata* - Gambetta, 1929: 64–72 - Chalchi
Levantina spiriplana malziana - K.L.Pfeiffer, 1949: 12–23 - Chalki, Alimia
Levantina spiriplana malziana - Frank, 1997: 113 - Alimía, Chálki

EXAMINED MATERIAL. Chalki, Chorio, 01.VIII.2014, 9 36°13'13"N-27°35'07"E, 268 m a.s.l., 2 shells juv; Chalki, Adramasos, VIII.2014, 36°13'32"N-27°34'48"E, 32 m a.s.l., 2 shells; Chalki, Pefkia, 02.VIII.2014, 36°14'15"N-27°36'53"E, 125 m a.s.l., 4 shells (3 juvenes).

DISTRIBUTION AND BIOLOGY. *Levantina spiriplana* s.l. has an Eastern Mediterranean distribution: Dodecanese (from Kálimnos to Rhodes and Kárpathos), South-West Turkey, from Syria to Palestine and Cyprus, probably dispersed also by man. It lives mainly on rocks, but also in other habitats.

REMARKS. All the adult shells of *Levantina* collected on Chalki had closed umbilicus, therefore we classify them as subspecies *malziana* (Fig. 54), in the nominotipycal subspecies the umbilicus is partially covered.

Genus *Eobania* P. Hesse, 1913

Eobania vermiculata (O.F. Müller, 1774)

Eobania vermiculata - Gambetta, 1929: 57–64 - Calchi
Eobania vermiculata - Frank, 1997: 103 - Halki

Examined material. Alimia, VIII.2014, 36°16'5"N-27°42'12"E, 31 m a.s.l., 3 shells; Chalki, Adramasos, VIII.2014, 36°13'32"N-27°34'48"E, 32 m a.s.l., 3 shells.

Distribution and Biology. *Eobania vermiculata* has Mediterranean distribution, and lives on every island in the South Aegean (Gambetta, 1929). It occurs in a broad variety of habitats, also anthropized sites.

Remarks. It is common on Chalki and Alimia, on the ground among the rocks, with shells caractherized by thick and well reflected peristome.

Genus *Cantareus* Risso, 1826

Cantareus apertus (Born, 1778)

Helix (*Pomatia*) *aperta* - Von Martens, 1889: 196 - insel Chalki
Helix (*Helicogena*) *aperta* - Gude, 1902: 124 - Kharki (Chalki)

Examined material. Chalki, Pefkia, 02.VIII.2014, 36°14'15"N-27°36'53"E, 125 m a.s.l., 1 shell.

Distribution and Biology. *Cantareus apertus* has a Mediterranean distribution, from France in the west to Greece and Aegean islands in the east, and from Italy in the north to the Mediterranean Africa in the south. It is a thermophilic species more common in argillaceous and marly soils, where it estivates buried in the soil.

Remarks. A shell was sampled up by us at Pefkia (Fig. 55) and few living specimens were observed at Imborios.

Genus *Cornu* Born, 1778

Cornu aspersum (O.F. Müller, 1774)

Examined material. Chalki, Adramasos, VIII.2014, 36°13'32"N-27°34'48"E, 32 m a.s.l., 2 shells.

Distribution and Biology. West European-Holomediterranean distribution, dispersed by man all over the world. *Cornu aspersum* occurs in many different kinds of biotopes, coastal retrodune, open grasslands, woods, rocky ground, anthropized sites.

Remarks. This species is probably native of the south-western Mediterranean regions (Algeria, Tunisia, Sicily). In this area populations of *C. aspersum* from different locality show differences among the relative dimensions of some parts of the genitalia and also substantial genetic differences (Guiller & Madec, 2010; Colomba et al., 2015). Such differences point out the necessity of further taxonomic studies.

The past authors have not reported this big Helicidae for Chalki, therefore it is probably a recent introduction (Fig. 56). Few living specimens were observed at Imborios.

Genus *Helix* Linnaeus, 1758
Subgenus *Helix* Linnaeus, 1758

Helix* (*Helix*) *pronuba Westerlund et Blanc, 1879

Helix (*Helix*) *pronuba* - Neubert, 2014: 120–126 - Chalki Island (SMF/8, NMBE 528722/3)

Distribution and Biology. This species is known from Crete, Karpathos, Chalki Island, and Northern African coast, from Egypt to Tunisia (see Neubert, 2014).

Subgenus *Pelasga* Hesse, 1908

Helix* (*Pelasga*) *nucula Mousson, 1854

Helix (Pelasga) *nucula* - Neubert 2014: 151-160 - Chalki, 36.2234, 27.6114, 02.06.1996

Distribution and Biology. East Mediterranean distribution: South-Eastern Aegean Islands, Mediterranean Turkish coast from Izmir to Manavgat, and Cyprus (Neubert, 2014). *Helix nucula* is widespread on the Aegean Islands, and Triantis et al. (2004) report it also as fossil. It is report for Chalki only by Bank (2011).

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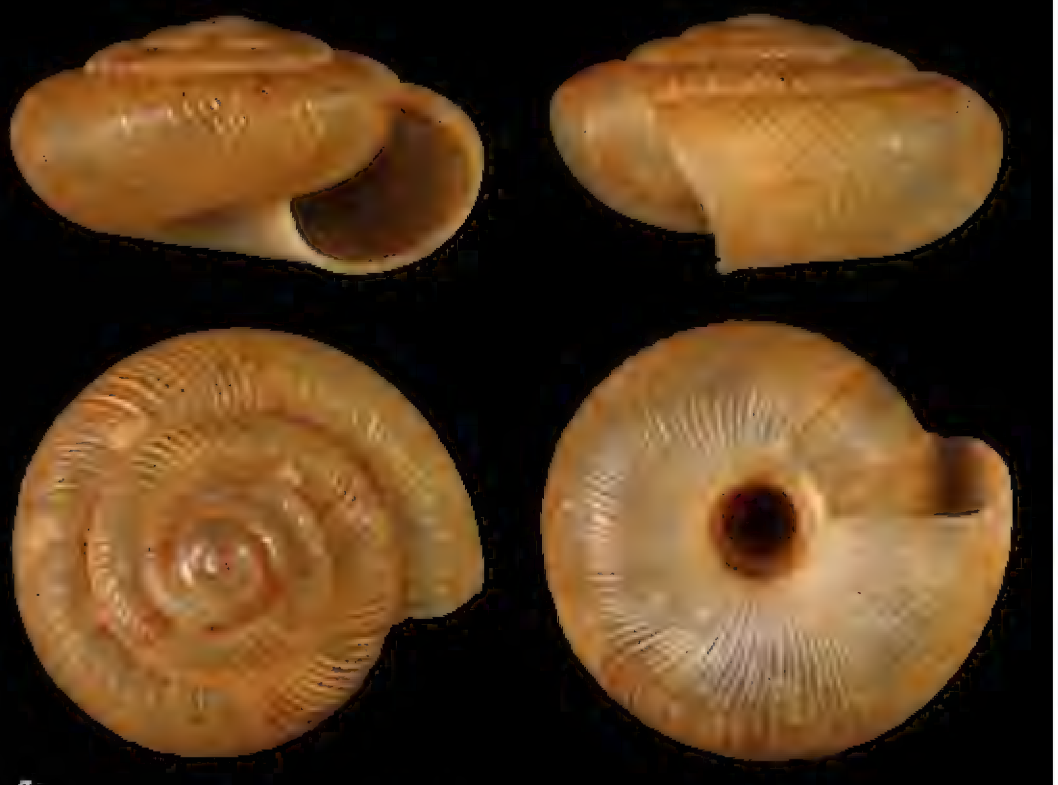
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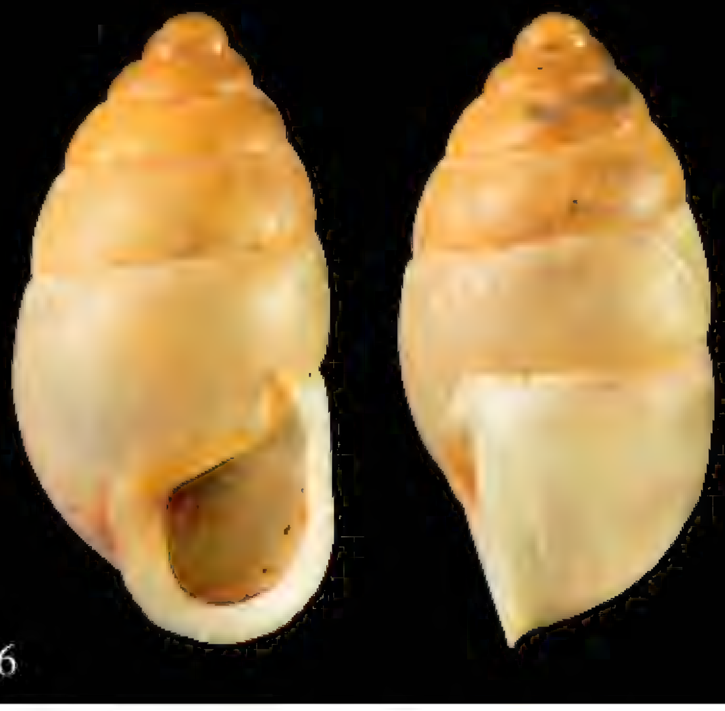
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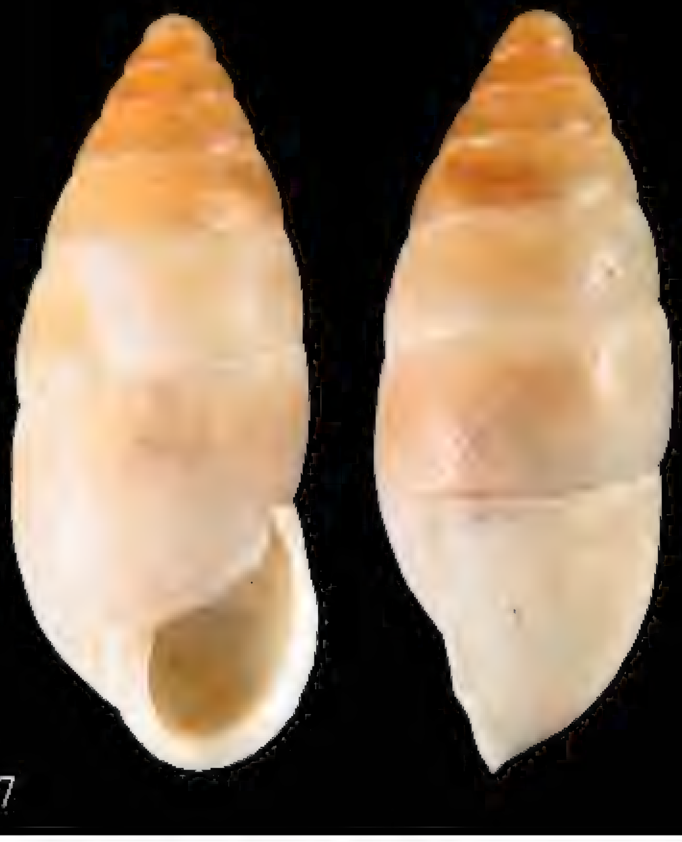
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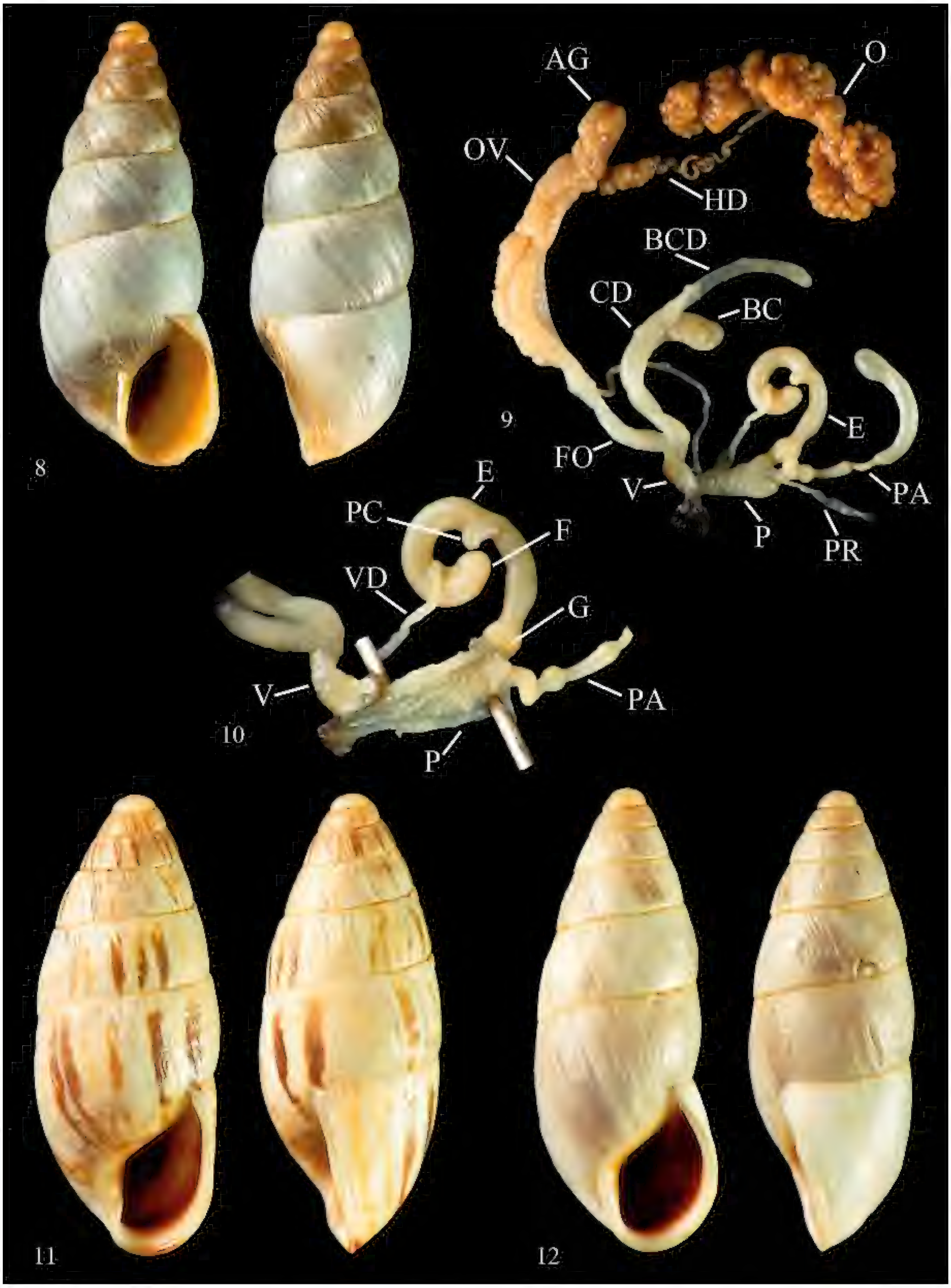
Figure 2. Coastal vegetation of the islet of Alimia. Figures 3, 4. limestone outcrops of Chalki Island. Figure 5. *Pleurodiscus balmei*, Chalki Island, Chorio, H: 4.76 mm, D: 7.9 mm. Figure 6. *Mastus emarginatus turgidus*, Alimia Islet, H: 11.33 mm, D: 5.9 mm. Figure 7. *Mastus* sp., Chalki Island, Xerokambos, H: 16.6 mm, D: 6.6 mm.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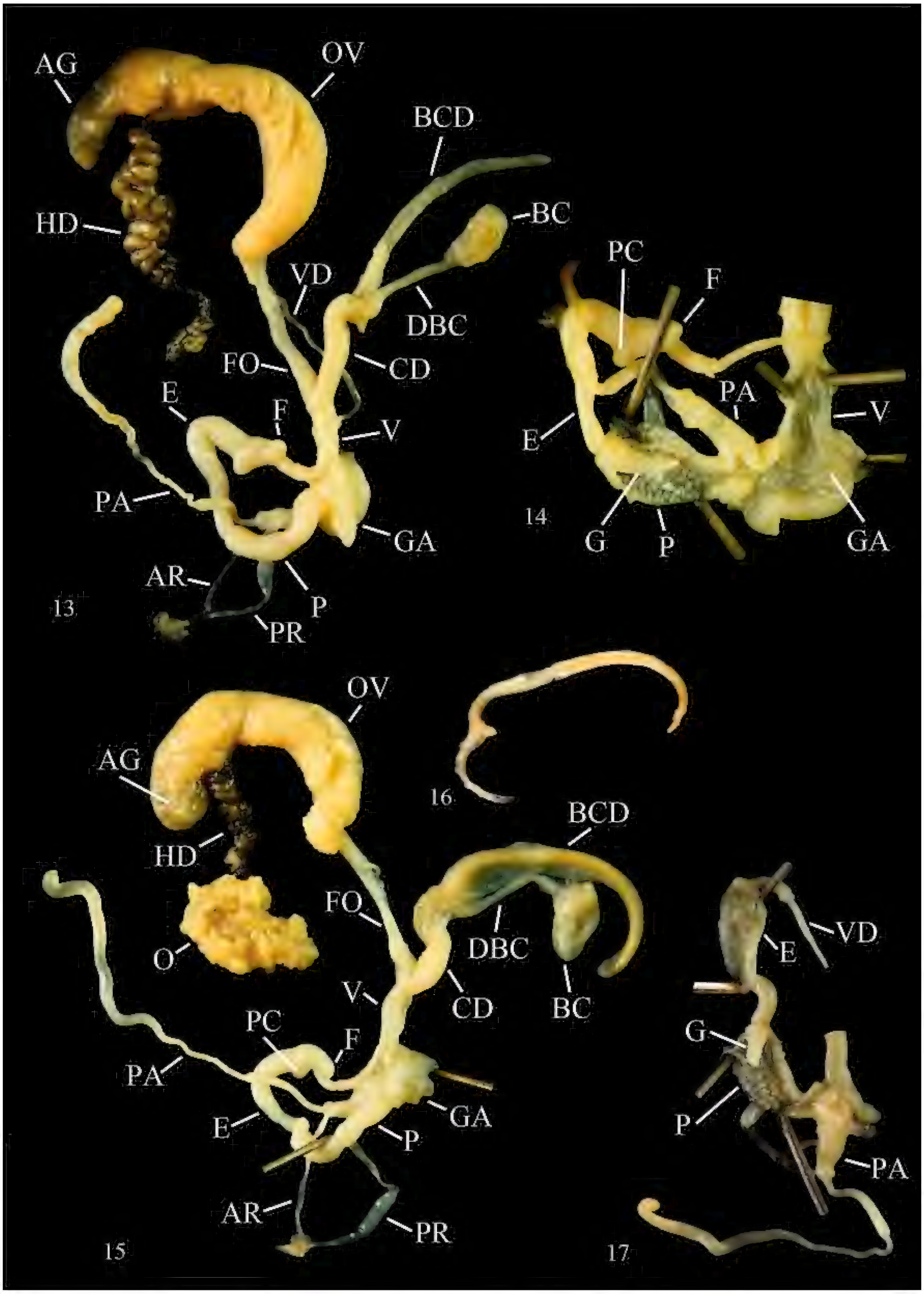
Figures 8–10. *Rhabdoena cosensis*, Greece, Dodecanese, island of Chalki, Chorio. Fig. 8: shell, H: 17.3 mm, D: 7.25 mm, Fig. 9: genitalia, Fig. 10: internal structure of penis. Figures 11, 12. *Zebrina fasciolata*, Greece, Dodecanese, island of Chalki, Kania: Fig. 11: shell, H: 15.8 mm, D: 6.32 mm. Fig. 12: shell, H: 24.2 mm, D: 12.7 mm.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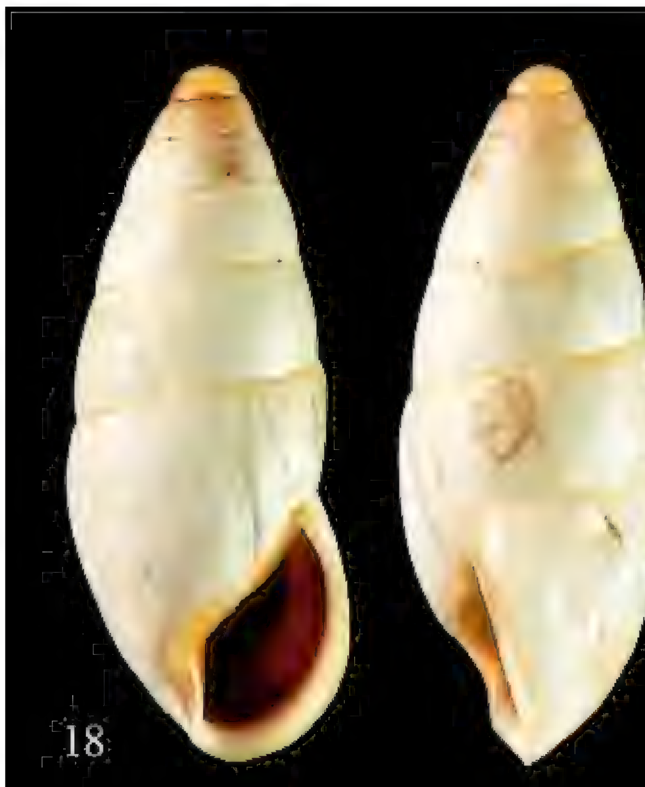
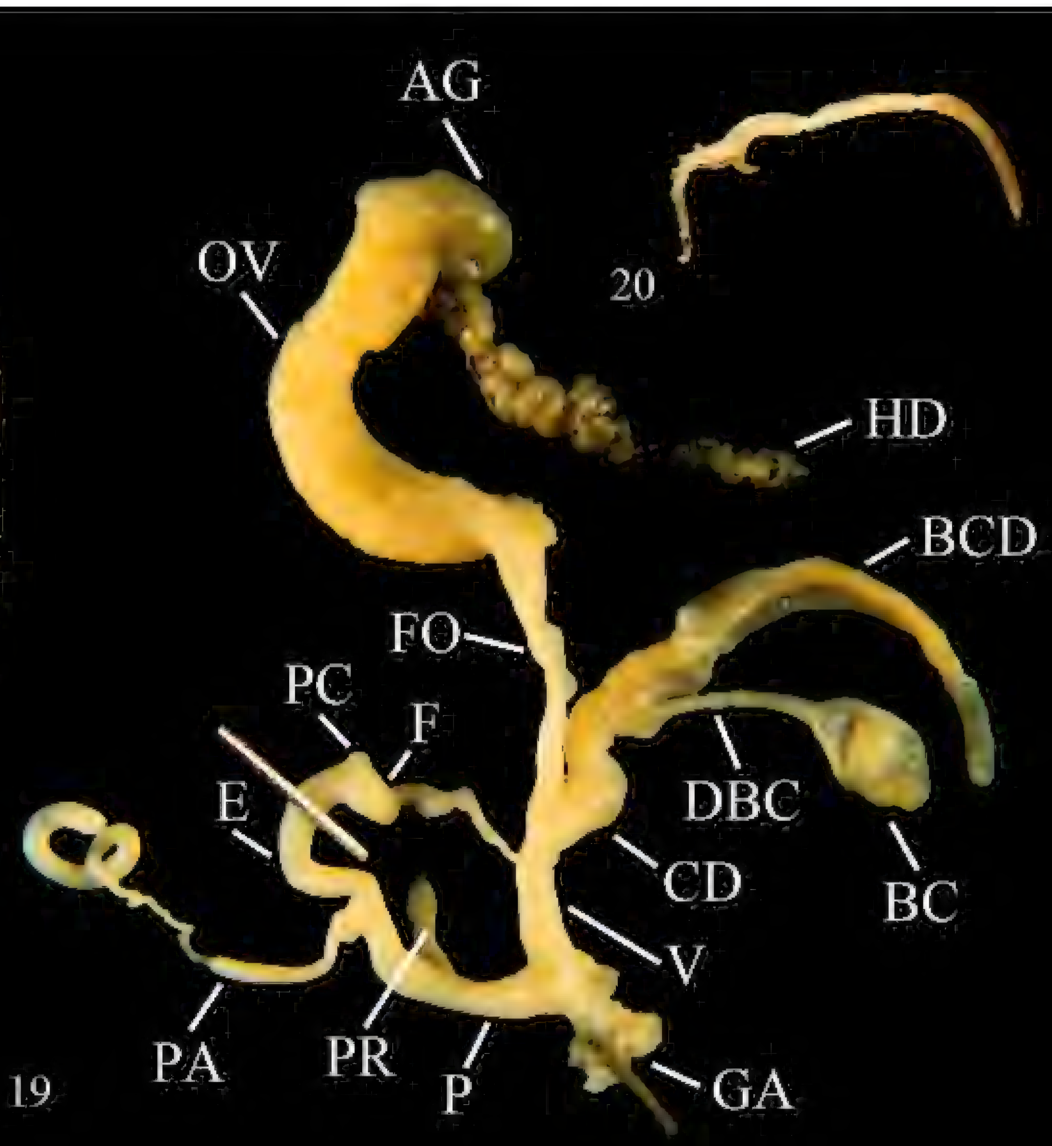
Figures 13, 14. *Zebrina fasciolata*, (same specimen of figure 12), Fig. 13: genitalia, Fig. 14: internal structure of penis. Figures 15–17. *Zebrina fasciolata*, Greece, Dodecanese, island of Chalki, Kania. Fig.15: genitalia. Fig. 16: spermatophore. Fig. 17: internal structure of penis.

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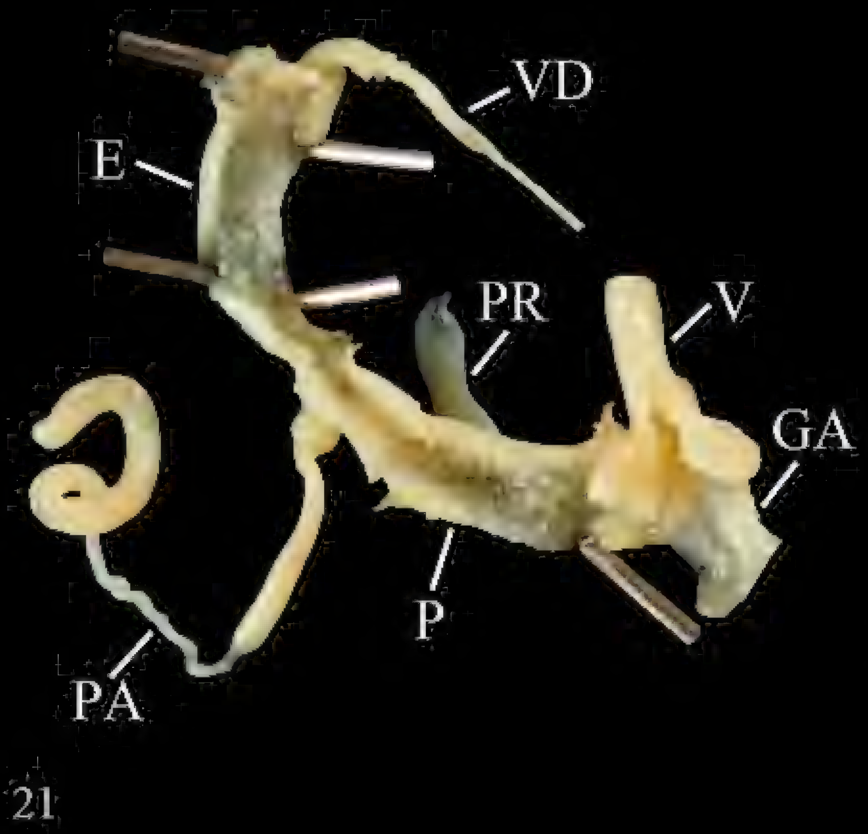
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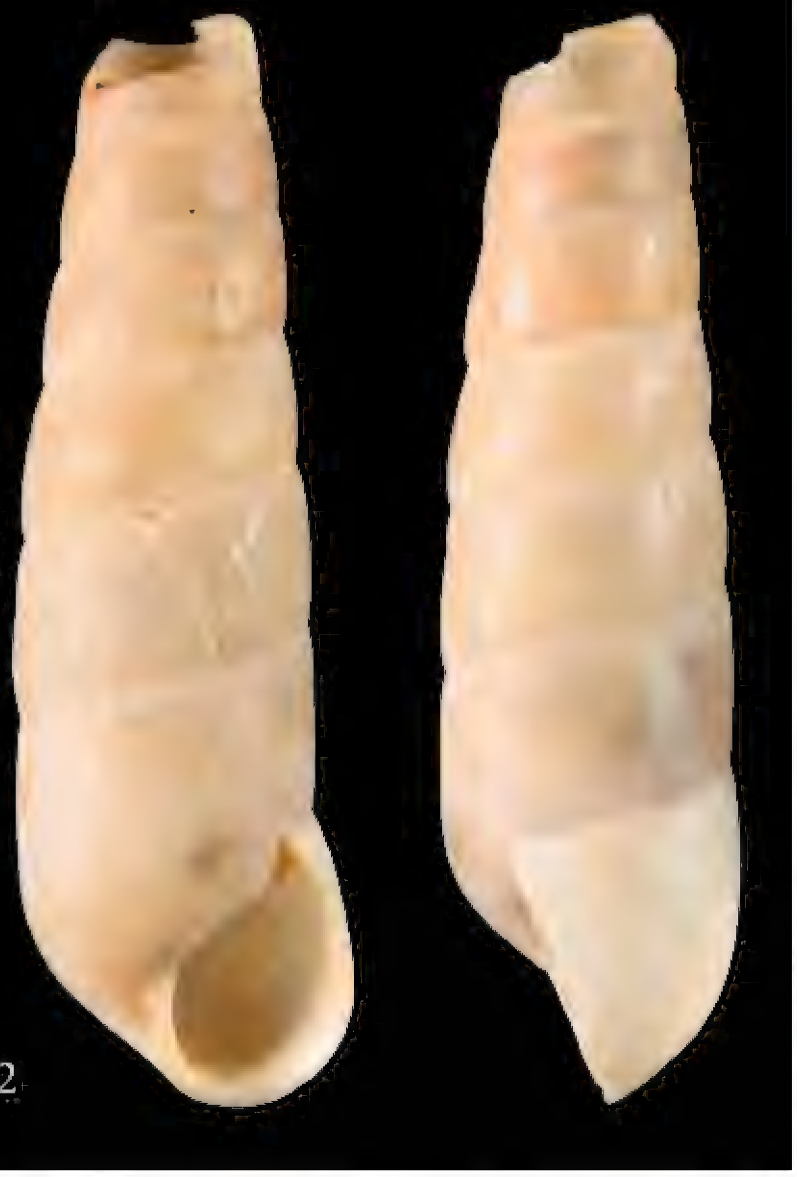
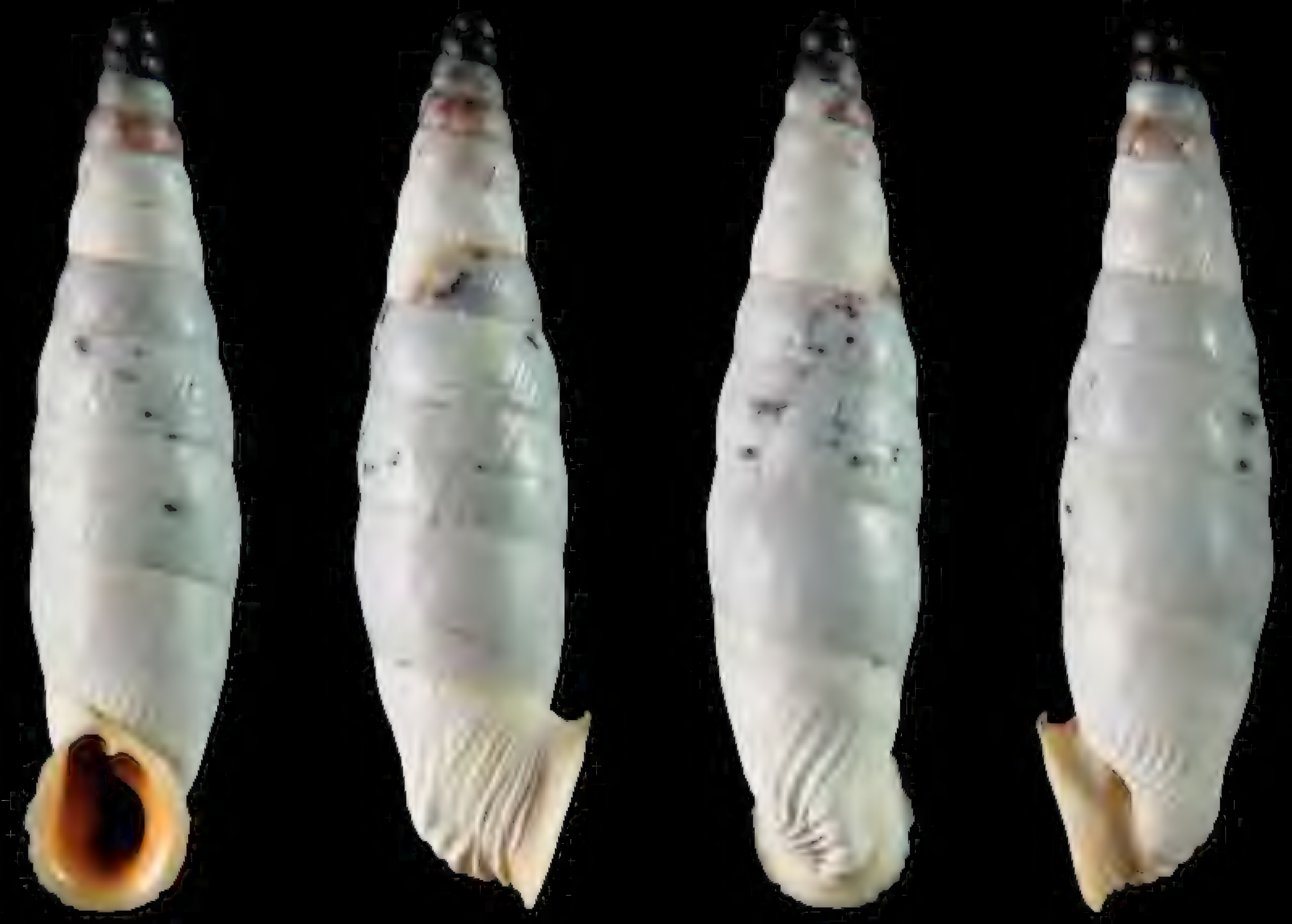


Figures 18–21. *Zebrina candida*, island of Chalki, Kania. Fig. 18: shell. H: 18.6 mm. D: 12.3 mm. Fig. 19: genitalia. Fig. 20: spermatophore. Fig. 21: internal structure of penis. Figure 22. *Rumina* cf. *saharica*, Greece, Dodecanese, Alimia Islet, H: 24.8 mm, D: 7.7 mm.



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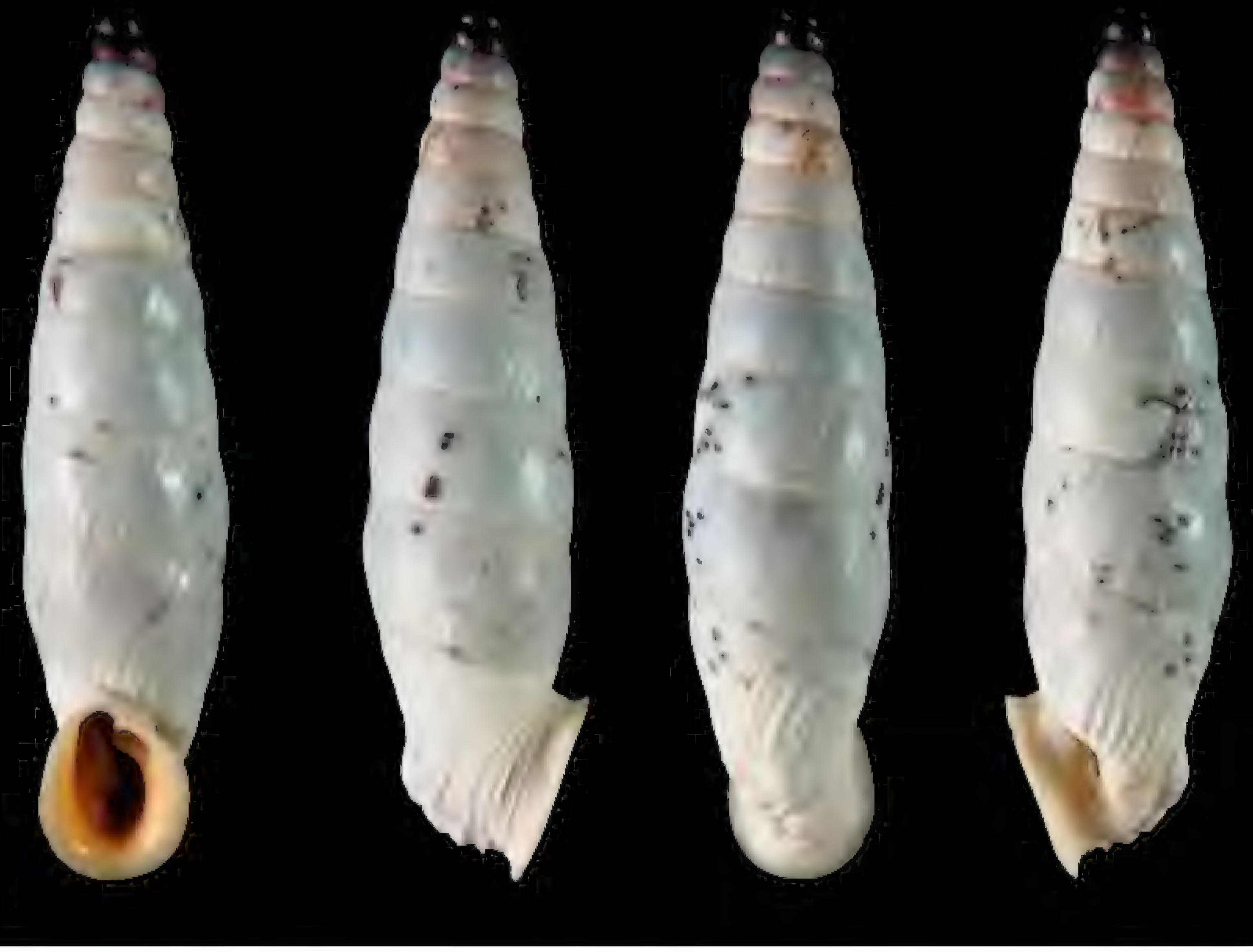

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Figures 23, 24. *Albinaria* (*Albinaria*) *brevicollis chalcidensis*, island of Chalki, Chorio. Fig. 23: shell, H: 17 mm, D: 4 mm. Fig. 24: shell, H: 16 mm, D: 3.8 mm.

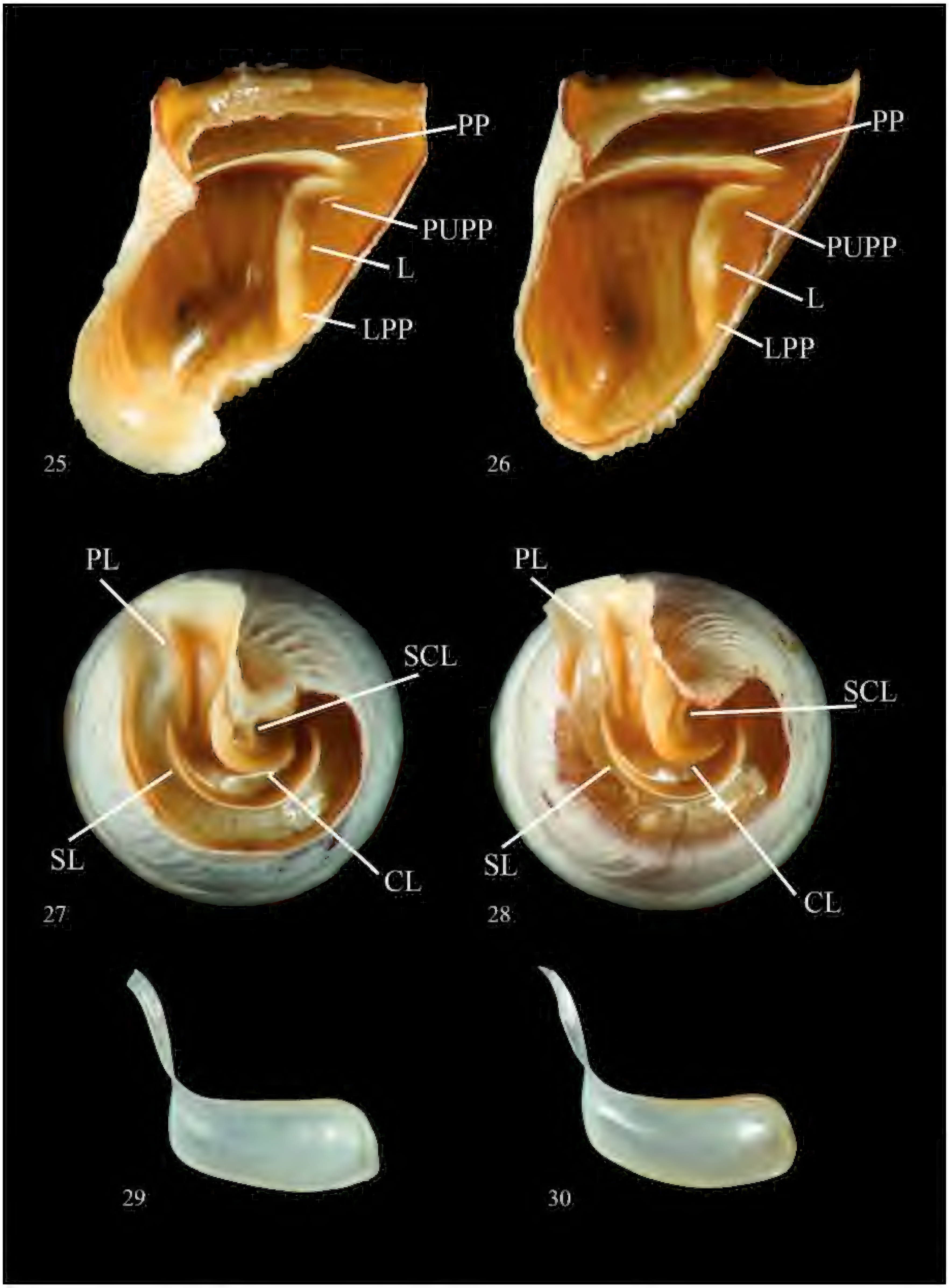
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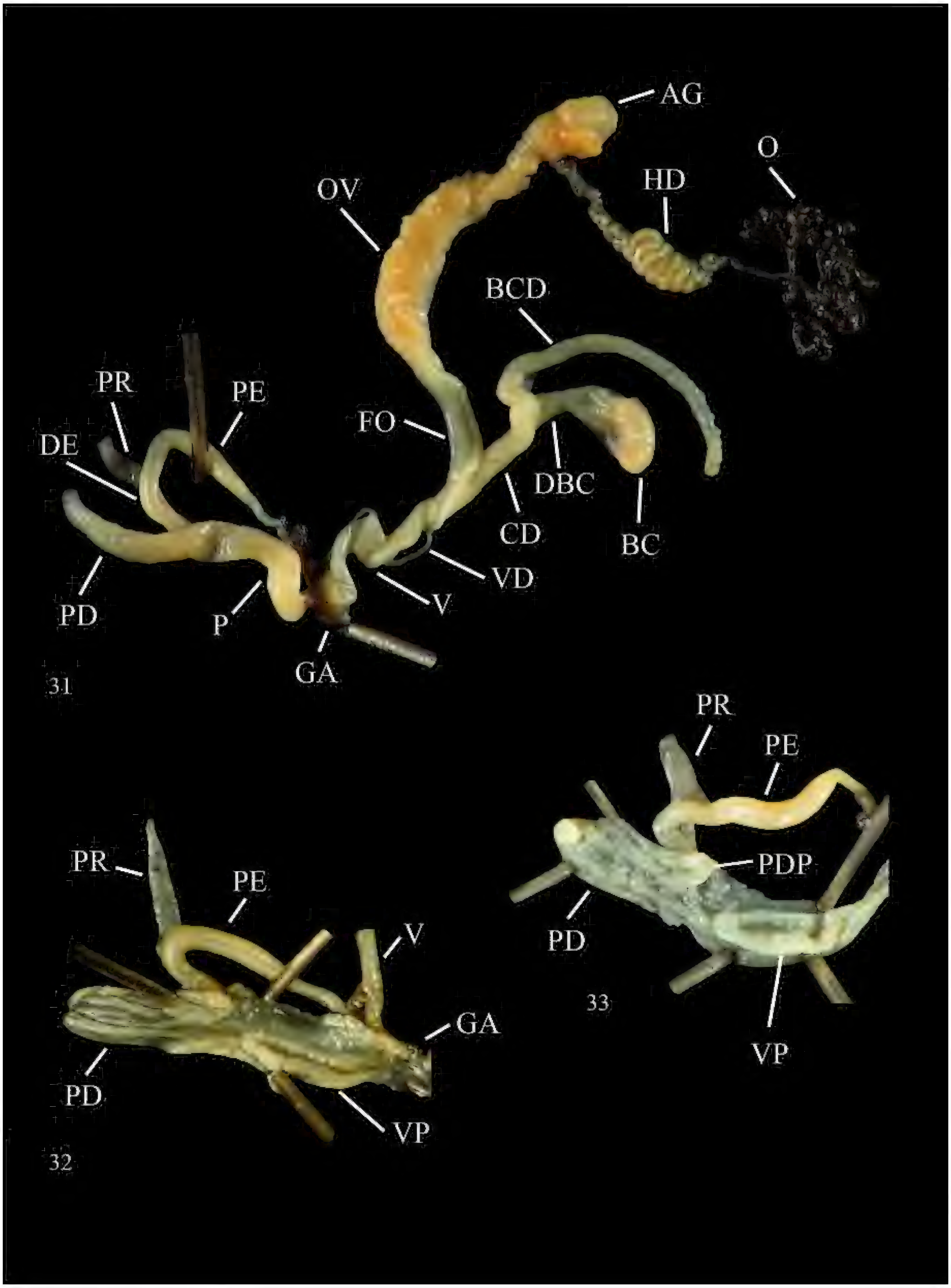
Figure 25–30. *Albinaria* (*Albinaria*) *brevicollis chalcidensis*, island of Chalki, Chorio. Figs. 25-26: palatum. Figs. 27, 28: parietum. Figs. 29, 30: clausilium.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Figures 31–33. *Albinaria* (*Albinaria*) *brevicollis chalcidensis*, island of Chalki, Fig. 31: Chorio, genitalia. Fig. 32: Plaghia, internal structure of penis. Fig. 33: Chorio, internal structure of penis.

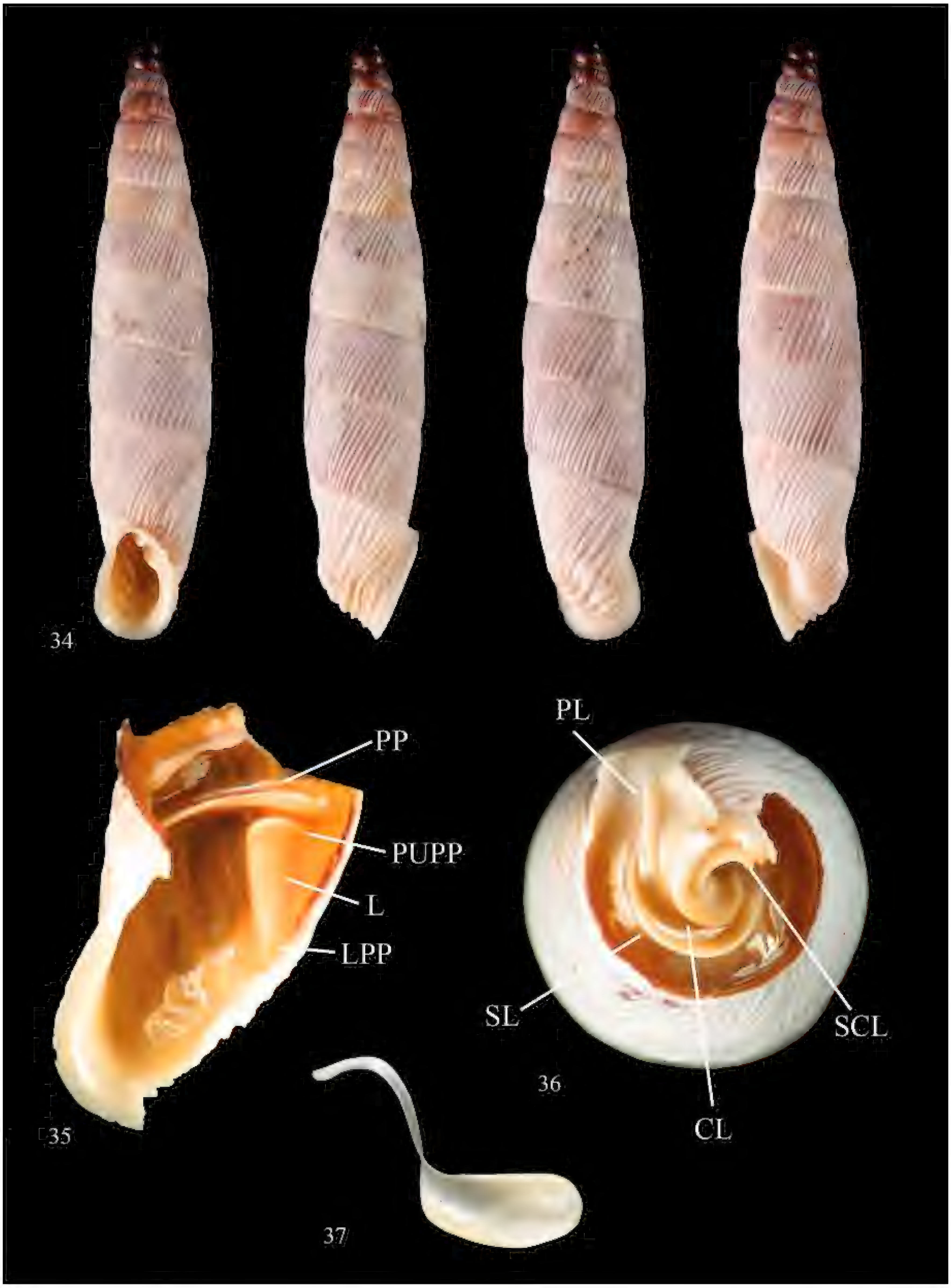
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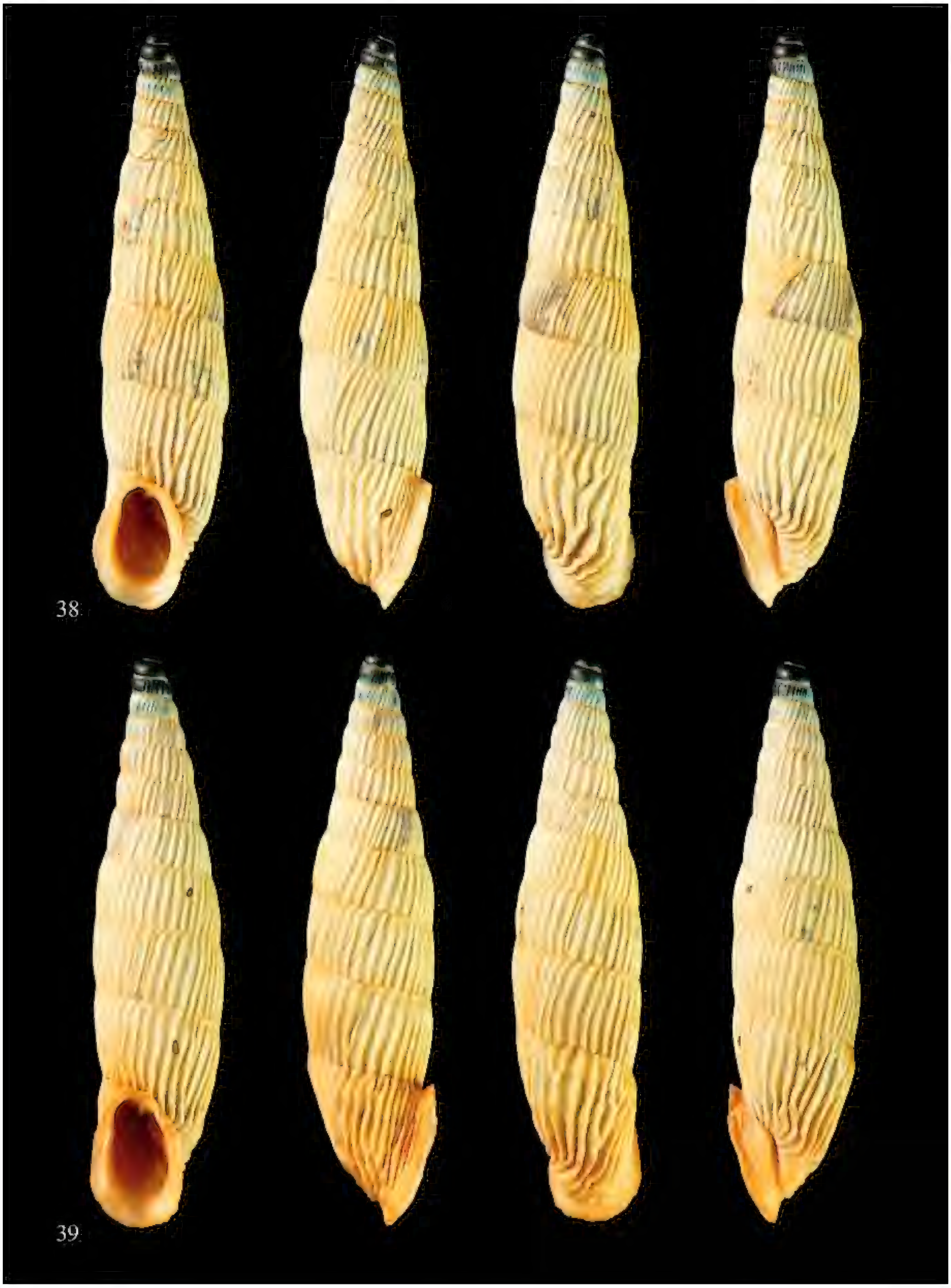
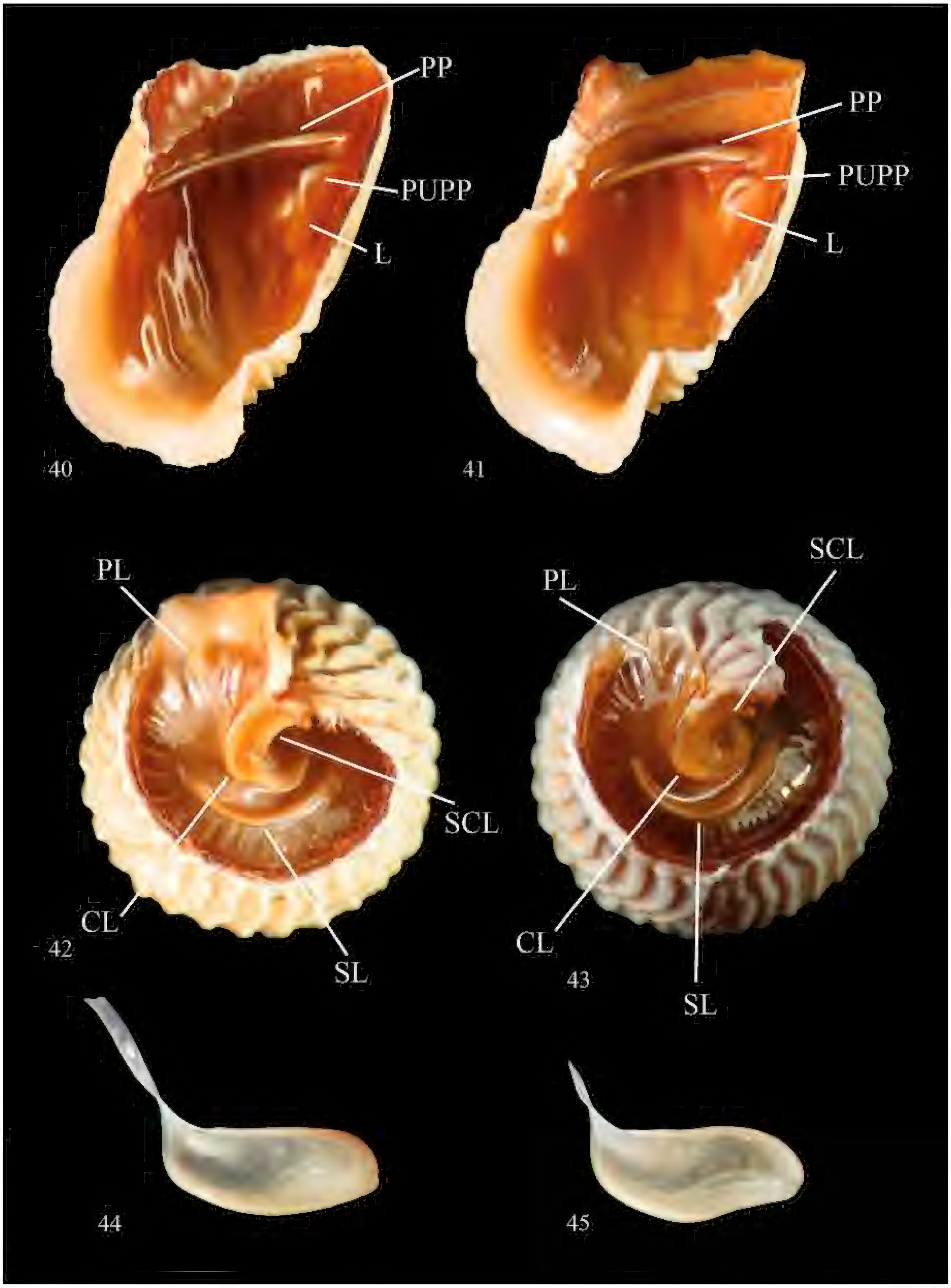
Figure 34–37. *Albinaria* (*Albinaria*) *brevicollis superba*, Alimia Islet. Fig. 34: shell, H: 17 mm, D: 3.4 mm. Fig. 35: palatum. Fig. 36: parietum, Fig. 37: clausilium.



Figures 38, 39. *Albinaria* (*Mirabellina*) *teres nordsiecki*, island of Chalki, Zies, Fig. 38: shell, H: 17.03 mm, D: 3.9 mm. Fig. 39: shell, H: 17 mm, D: 3.9 mm.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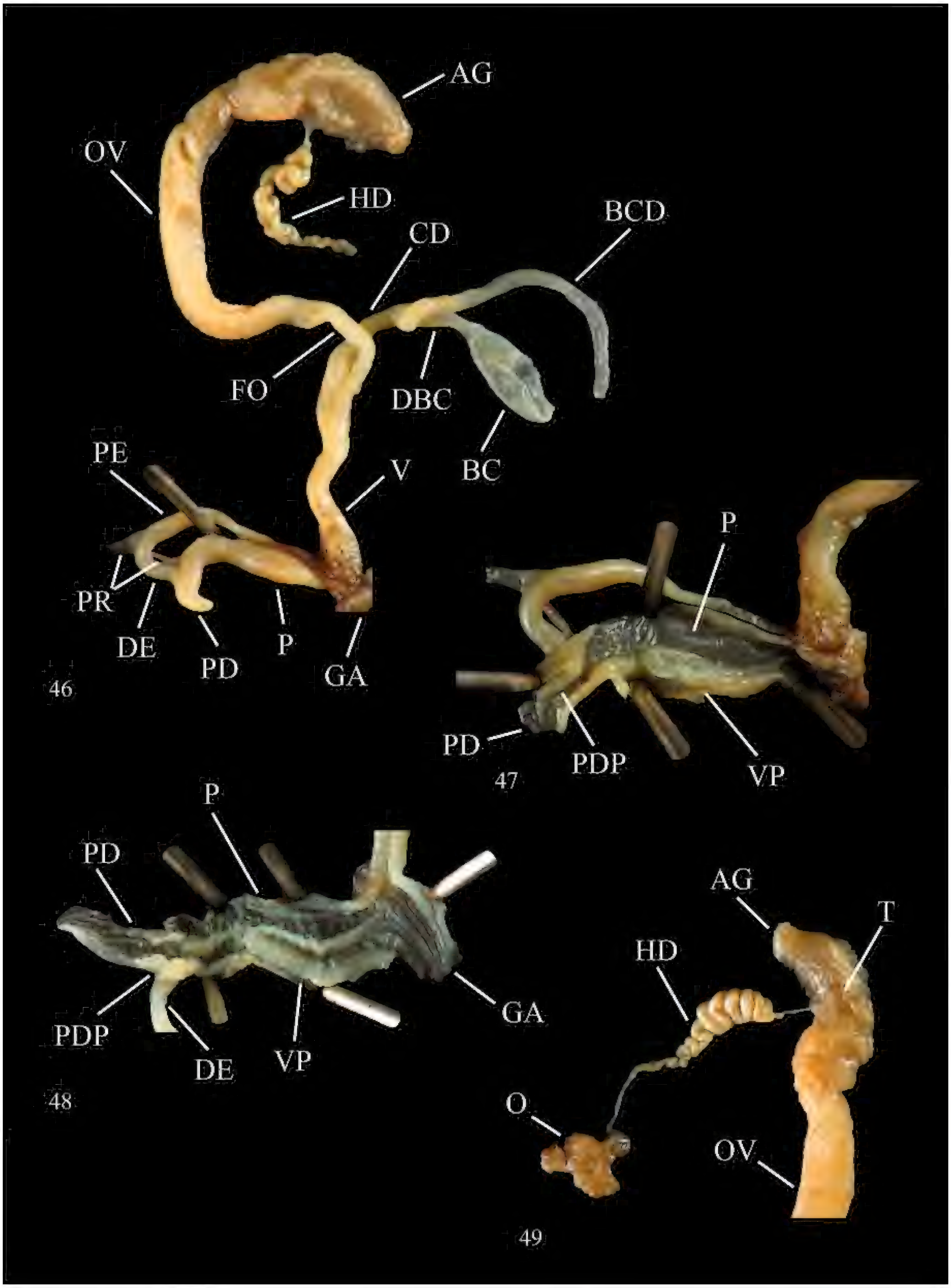
Figures 40–45. *Albinaria* (*Mirabellina*) *teres nordsiecki*, island of Chalki, Zies, Figs. 40, 41: palatum, Figs. 42, 43: parietum, Figs. 44, 45: clausilium.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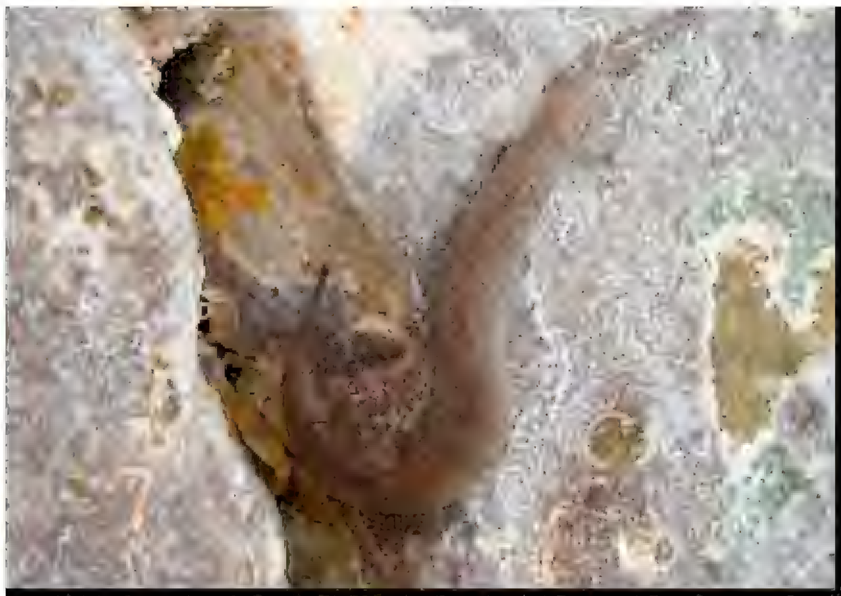
Figures 46–49. *Albinaria* (*Mirabellina*) *teres nordsiecki*, island of Chalki, Zies, Fig. 46: genitalia. Fig. 47: internal structure of penis (same specimen of figure 46), Fig. 48: internal structure of penis. Fig. 49: proximal female genitalia.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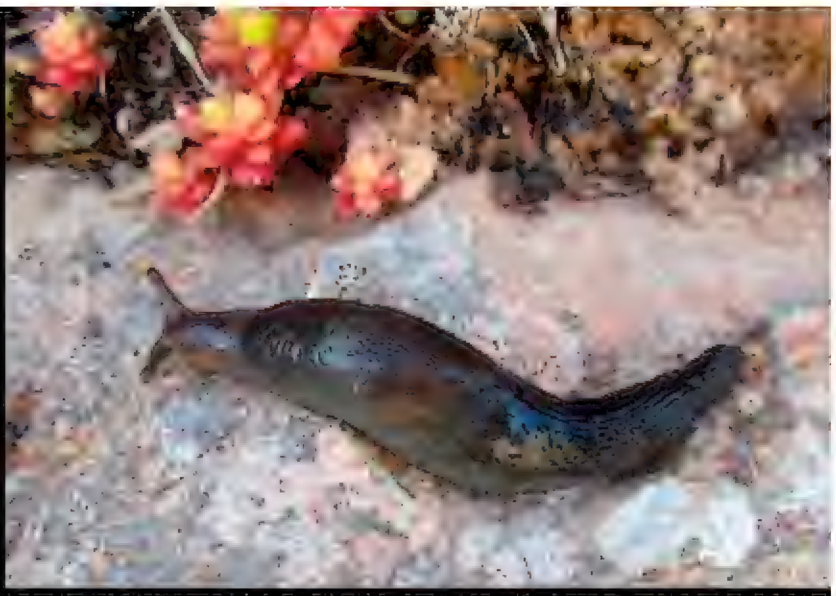
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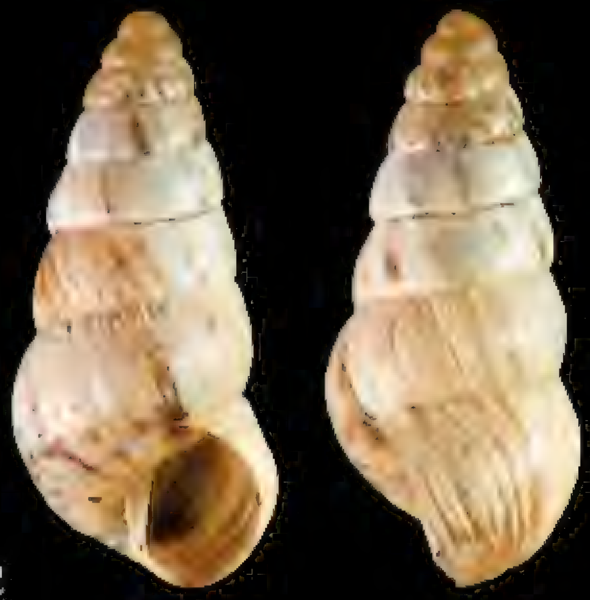
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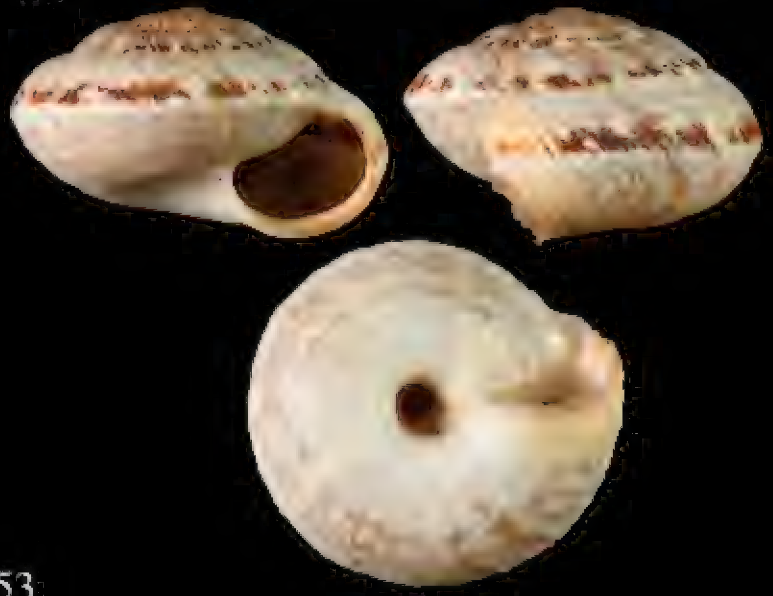
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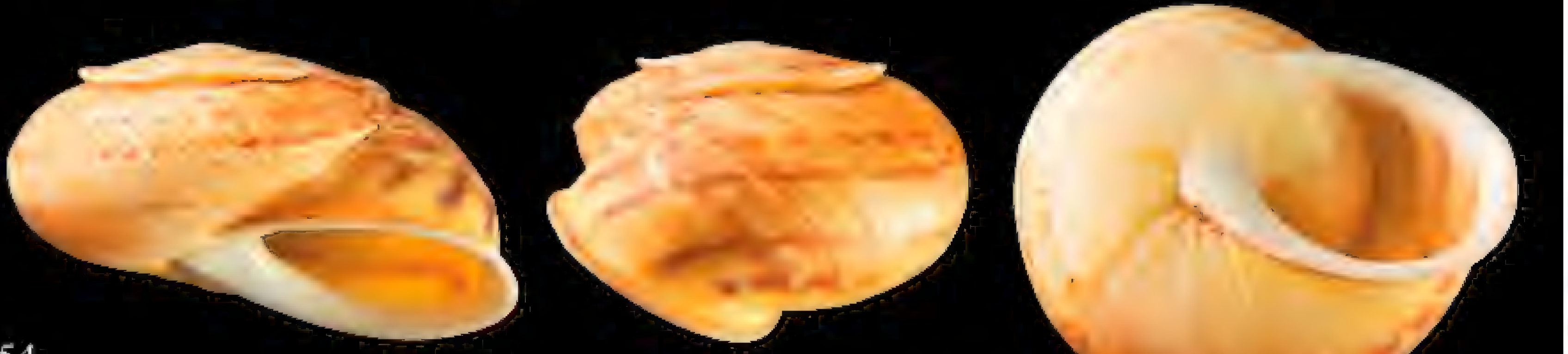
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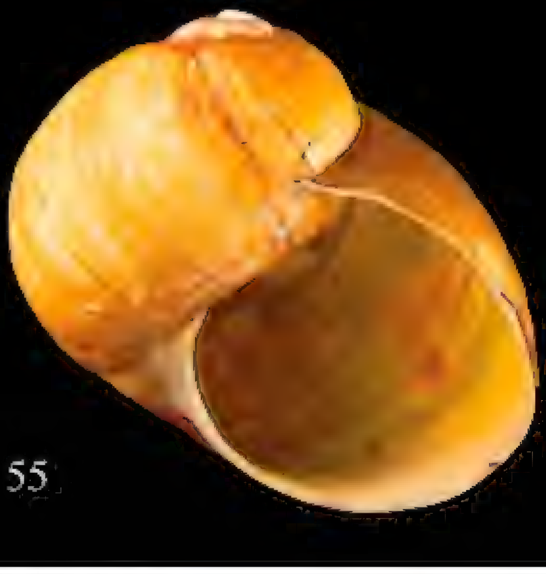
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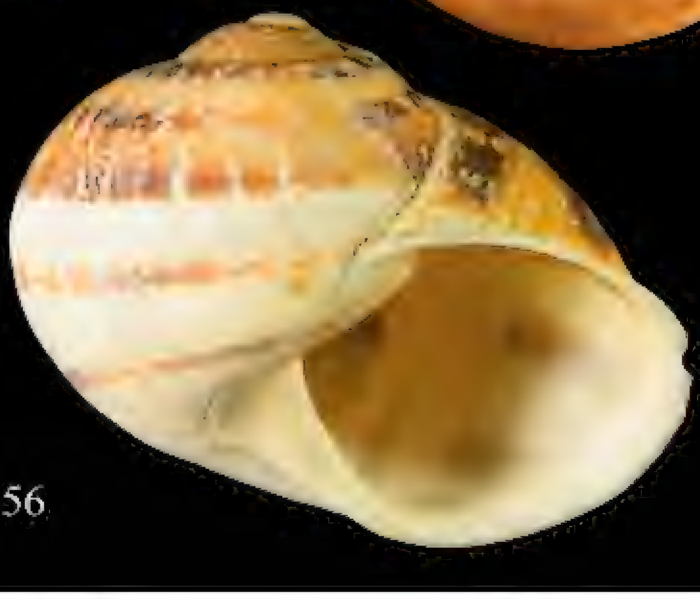
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Figure 50. *Tandonia* cf. *pageti*, island of Chalki, Chorio, length: 8 cm. Figure 51. *Deroceras* (*D.*) cf. *samium*, island of Chalki, Imborios, length: 40 mm. Figure 52. *Cochlicella* (*C.*) *acuta*, island of Chalki, Imborios, H: 8.5 mm, D: 3.8 mm. Figure 53. *Xerocrassa* (*X.*) *meda* (Porro, 1840), island of Chalki, Ag. Ghiorgos, H: 5.1 mm, D: 8.3 mm. Figure 54. *Levantina* (*L.*) *spiriplana malziana*, island of Chalki, Pefkia, H: 27.5, D: 16.5 mm. Figure 55. *Cantareus apertus*, island of Chalki, Pefkia, H: 25.5 mm, D: 26.3 mm. Figure. 56. *Cornu aspersum*, island of Chalki, Adramasos, H: 32 mm, D: 39 mm.

CONCLUSIONS

Based on our own findings and the results from previous molluscan studies, the malacofauna of Chalki comprises 23 extant taxa and that one of Alimia 6.

Twenty-one species of land snails were collected during our surveys in the two islands, however three species recorded by past authors have not been found by us (*Orculella cretica*, *Helix nucula* and *H. pronuba*).

Ten species are new records for Chalki and four for Alimia (Table 1). Among the new records *Pleurodiscus balmei* is represented only as an empty juvenile shell, therefore further researches are needed to confirm the presence of a living population. Two shells of an unidentified *Mastus* are reported as *Mastus* sp.

From all localities sampled in Chalki, the richest was Chorio with five species, followed by Adramasos, Ag. Ghiorgos and Kania with three species.

As far as endemic species are concerned there's only a strict endemic species, *Albinaria* (*A.*) *brevicollis chalcidensis*. Two species are endemic of Rhodes and respectively also of Chalki: *Zebrina candida* and of Alimia *Albinaria* (*A.*) *brevicollis superba*. An endemic species of the Dodecanese, *Mastus emarginatus turgidus* is present both on Chalki and Alimia. Five species are endemic for the Aegean

SPECIES	CHOROTYPE	CHALKI		ALIMIA	
Orculella critica	Aeg-Grek	L			
Pleurodiscus balmei	E-Med		NR		
Mastus emarginatus turgidus	Dod	X			NR
Mastus sp.	---		NR		
Rhabdoena cosensis	Aeg	X			
Zebrina fasciolata	E-Med		NR		
Zebrina candida	Dod		NR		
Rumina cf. *saharica*	E-Med	X			NR
Albinaria (*Albinaria*) *brevicollis chalcidensis*	End	X			
Albinaria (*Albinaria*) *brevicollis superba*	Dod			X	
Albinaria (*Mirabellina*) *teres nordsiecki*	Aeg	X			
Eopolita protensa protensa	Aeg	X			
Tandonia cf. *pageti*	Aeg		NR		
Deroceras (*Deroceras*) cf. *samium*	Aeg		NR		
Cochlicella (*Cochlicella*) *acuta*	Eur		NR		
Xerocrassa (*Xerocrassa*) *cretica*	E-Med	X			NR
Xerocrassa (*Xeroclausa*) *meda*	Med		NR		
Metafruticicola (*Metafruticicola*) *pellitus pellitus*	Aeg	X			
Levantina (*Levantina*) *spiriplana malziana*	E-Med	X		L	
Eobania vermiculata	Med	X			NR
Cantareus apertus	Med	X			
Cornu aspersum	Eur-Med		NR		
Helix (*Helix*) *pronuba*	E-Med	L			
Helix (*Pelasga*) *nucula*	E-Med	L			
TOTAL		14	9	2	4

Table 1. List of species of Chalki and Alimia and their chorotype. L = data of literature, NR = new record, X = our findings.

region, and *Orculella critica* for the Greek-Aegean regions. Moreover, eight species present a wide eastern Mediterranean distribution, either Mediterranean (three species), or Mediterranean European (two species) (Table 1). Therefore the Eastern Mediterranean elements is the most represented chorotype in Chalki (34.8 %).

We consider *Cornu aspersum* to be of recent introduction for Chalki, since this large Helicidae was not sampled by past authors and it has on Chalki limited ranges restricted to stations near present or past human dwellings. To the list of non-native species we tentatively added also *Xerocrassa meda*, which is known in Aegean region only for Kos and Lesvos as an introduced species.

These findings show a close relationship of the molluscan fauna between Chalki, Alimia and that of the nearby island of Rhodes. All sampled species in Alimia are also present in Rhodes, while of the twenty-three species listed for Chalki only four are not present in Rhodes: *A. brevicollis chalcidensis* endemic species of Chalki, *A. teres nordsiecki* species native to the island of Crete, *X. meda* perhaps introduced in Chalki, and *Mastus* sp. whose status remains uncertain. We have redescribed the shell of *A. brevicollis chalcidensis* and for the first time we have described and illustrated its genitalia. For the first time we have also described in detail the internal genitalia of *R. cosensis*, *Z. fasciolata*, *Z. candida* and *A.* (*M.*) *teres nordsiecki.* Further investigations are nevertheless necessary to ascertain the specific status both of the slugs and of *O. critica*.

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Benthos communities of Vendicari and Capo Passero, two potential MPA's in South Eastern Sicily (Italy)

Vincenzo Di Martino[1*] & Bessy Stancanelli[2]

[1]CNR / I.S.A.Fo.M. - U.O.S. di Catania, via Empedocle 58, 95128 Catania, Italy
[2]AQUA STORIES - via Vampolieri 25/31, 95022 Aci Catena, Catania, Italy
[*]Corresponding author, e-mail: vincenzo.dimartino@cnr.it

ABSTRACT In the present paper a bionomic study and cartography of the benthos of two potential MPAs in South Eastern Sicily, S.C.I. ITA 090027 "Fondali di Vendicari" and the S.C.I. ITA 090028 "Fondali dell'Isola di Capo Passero", and surrounding areas are presented. The goals of this particular survey can be summarized as follows: 1) to chart the benthic communities (and the area of each one); 2) to evaluate the benthic diversity of the areas; 3) to produce visual documentation of the distributions of the benthic organisms; 4) to identify human-induced pressures on the benthic environment; 5) to make recommendations for future management based on the visual assessment; and 6) to set up a new methodology for making large biocenosis maps that would help to manage marine protected and non-protected areas. The fauna and flora of the meso- and macrobenthos were studied by a triple sampling procedure: standard, visual and photographic samples were simultaneously taken along underwater transects. These, together with the floristic and faunistic study of each algal and invertebrate group, served as the basis for the bionomic survey of the Vendicari and Capo Passero Island sea bottoms. In a first approach, the supra- and mediolittoral communities were studied. Further work were focused on the infralittoral stages and their communities along representative transects. The survey was conducted from surface (+0.50 m) to 40 metres of depth that is the limit of the study site. During this study were found, also, 41 benthic species and many biocoenoses of high naturalistic value protected by many international law agreements. The study led to a comprehensive review of the main biotope systems of this coastal area, as well as their environmental condition, and this will be an essential element for their future management.

KEY WORDS marine protected areas; benthos communities; biocenotic map; SE Sicily; endangered species.

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INTRODUCTION

Natural ecosystems and landscapes that provide benefits to human society are of great ecological, socio-cultural and economic value (Costanza et al., 1997; de Groot et al., 2002). All these benefits, together with their support structure, constitute an ecosystem's natural capital. However, the benefits of natural capital have been ignored in land-use and marine planning and in decision-making processes.

Vendicari and Capo Passero are two high naturalistic values areas along south eastern sicilian shoreline.

Vendicari area falls within the territory of the municipality of Noto and includes a vast wetland separated from the sea by coastal dunes and a coastline characterized by sandy beaches that form rocky shores; little off there is a small island. Throughout this area in 1978 was declared a protected area by the Sicilian Region Law and was called "Riserva Naturale Orientata Oasi Faunistica di Vendicari". The bottom facing the coastal stretch of the protected area to a depth of 40 meters is the S.C.I. "ITA090027".

The Capo Passero Island is a small island located few hundred meters from the coast in front of the town of Porto Palo di Capo Passero (South of Siracusa) in the extreme south east of Sicily. The environment emerged of the Capo Passero Island is extremely rich in botanical species endemic and/or rarities such as the Italian Botanical Society has placed the island in the list of botanical habitats of particular value in Sicily. As a further demonstration of the importance of the environment emerged of the island it must be said that the entire emerged part of the island is the S.C.I. ITA090001. Are no exceptions the bottoms around the island, i.e. S.C.I. "ITA090028" characterized by the presence of large stands of *Pinna nobilis* (Linnaeus, 1758) and *Posidonia* beds. These two sites are among those set out in Italian Law 394/91, which contains the list of Italian areas that could become protected areas, marine and / or land, or national parks.

MATERIALS AND METHODS

Previous studies

The literature data on the marine surrounding areas near the natural riserve of S.C.I. ITA 090027 "Fondali di Vendicari" and the S.C.I. ITA 090028 "Fondali dell'Isola di Capo Passero" are very poor and incomplete.

In the past decades many studies were carried out on marine environment of nearby areas but no study was carried out, in particular, for the areas. The first paper on the Hyblaean coast was published by Battiato et al. (1980). In this study were examined only the floristic aspects on this marine environment. They founded 340 algal taxa.

Later, Giaccone et al. (1985a, 1985b; 1992) conducted studies on the marine vegetation present along coastline between Gela (South Sicily - Mediterranean Sea) and Capo Passero Island and between Capo Passero Island and Ognina di Siracusa (near Siracusa, southeastern Sicily - Ionian Sea). While Buia et al. (1985) published a study on epiphyte vegetation of *Posidonia* leaves present in the seabed of Capo Passero.

In the first '90th Scammacca et al. (1996 - internal report) conducted a research aimed at studying the effects of human activities related to land use and their effects on the coastal environments as part of the "P.O.P. - Sicilia 1990–93" research project.

Giaccone &Di Martino (1996) published the results of their research as updating of knowledge on the marine flora and vegetation along the Hyblean coast line.

Only in the 1999, Blundo et al. (1999 a, b) and Di Martino & Blundo (1999) published the results of their research aimed at the knowledge of the marine flora and vegetation of the marine sea bottoms of Vendicari.

Cantone (1997) published the first study on marine biocoenosis of the Vendicari marine sea bottoms with the grant by Sicilian Region and two year after Cantone et al. (1999) published the biocoenotic map of the Gulf of Noto (S-E Sicily - Ionian Sea). But in this map only two transects were carried out within the Vendicari marine area. The same data were analyzed by Cantone et al. (2000) with particular attention on muddy bottoms benthos.

Sampling methods and mapping

The benthic cartography of the two S.C.I. ITA090027 (Fig. 1) and ITA090028 (Fig. 2) was obtained by combining classical grabbing methods with more recent imaging methods (Bianchi et al., 2004). The grabbing methods were also used to collect biological material that was studied thoroughly in the laboratory to identify its components. Imaging methods allowed a much larger amount of information to be processed in the time available, and also permitted the quantification of some key landscape species (epibenthic organisms).

The benthic cartography presented in this paper includes information starting with supralittoral environments (30 cm above the mean sea level) down to a depth of 40 m in the circalittoral environment, and provides data for the distribution of the main benthic habitats found in the area. Additional information on species composition for these communities can be obtained from the cited literature.

The study of the benthos of Vendicari and of Capo Passero Island sea bottoms was carried out by underwater surveys. According to Tunesi & Vacchi (1993), Tunesi et al. (2001), Tunesi & Salvati (2002) and considering the type of coastal development of the two sites studied, it was decided to operate following the methodological approach commonly applied in similar studies to increase the knowledge of the sites for which it is proposed the establishment of a marine protected area.

To characterize the benthos of "Fondali di Vendicari" (S.I.C. ITA090027) were studied 20 transects orthogonal to the coastline. The spatial distribution of transects in the the coastline-sea direction was made in accordance with the homogeneity of benthic site as well as in consideration of the homogeneity of the coastline that has no major structural eminences if not in its portion to the north. In fact, in the most northern portion of this site transects were nearest to one another to better characterize the greater variety of biological submerged environments falling in this portion of the study area. Finally, to interpolate and enrich the data obtained was carried out the study of the biological communities present in a further 5 transects with orientation parallel to the coastline and long enough to intersect the largest possible number of the 20 transects orthogonal to the coast. In total for the seabed of Vendicari 100 surveys were carried out during the dive. 40 of these were made with the technique of "snorkeling" to study supralittoral, mediolittoral and fringe assemblages. The remaining 60 surveys were conducted by diving.

For the S.C.I. ITA090028 ("Fondali dell'Isola di Capo Passero") characterization were performed 12 transects orthogonal to the Island coastline and 15 transects with orientation parallel to the Island coastline to intersect the orthogonal transects. In total were performed 95 surveys of which 15 with the technique of "snorkeling" aimed at the study of the supralittoral and mediolittoral, the remaining 80 surveys have been conducted by diving with air breathing apparatus (SCUBA).

During all dives were carried out video and photographic surveys through the use of underwater digital and / or analog cameras and videocameras.

The information collected allowed to obtain the biocenotic map of the two S.C.I. ITA090027 and ITA090028 based on the IGM (Istituto Geografico Militare - Italian Army Geographical Institute) maps, at the 1:25,000 scale, suitably modified (Fig. 1). Similarly, it is made use of toponymy reported in the same maps. Each unit was represented by a bionomic campiture that, using different color layers defined by a code, refers to the RGB color scale graphics as proposed by Meinesz et al. (1983), implemented by Vaugelas et al. (1998) and, recently, enhanced by Tunesi et al. (2002) with those bionomic units that at the time of the realization of the two previous papers were not present.

The positioning of each transect in the two study areas was obtained through a GPS and using the geographic coordinate datum WGS 84.

RESULTS

Over the visual surveys were collected data on the presence of protected marine species and/or assemblages in the studied areas. The species considered were those receiving strict protection status according to Directive 79/409/CEE; Law 503, 5.10.81, Directive 92/43 CEE, 21.05.92, Presidential Decree 357, 8.09.1997, Law 157, 11.02.1992, and Law 175, 27.05.99. The marine habitats considered were those identified as "*determinant*" by UNEP (1999), which defines them as "*habitats for which conservation is considered indispensable*" (Amore et al., 1992; Relini, 2002; Furnari et al., 2003; Tunesi et al., 2008).

The census of protected species present in the studied areas was conducted by recording the presence of these species during the dives for the study of benthos integrated with the bibliographic data. It was also verified the presence of the species and/or marine benthic assemblages worthy of protection already reported in previous research (Cantone et al., 1993; Cantone, 1996, 2001; Blundo et al., 1999a, b; Di Martino & Blundo, 1999).

S.C.I. ITA090027 - Fondali di Vendicari

Due to the tipology of the coastal development of this site was made a division into three sectors (A, B and C) of the entire coastline.

The section "A" includes the northernmost portion of the site where the coastline is characterized

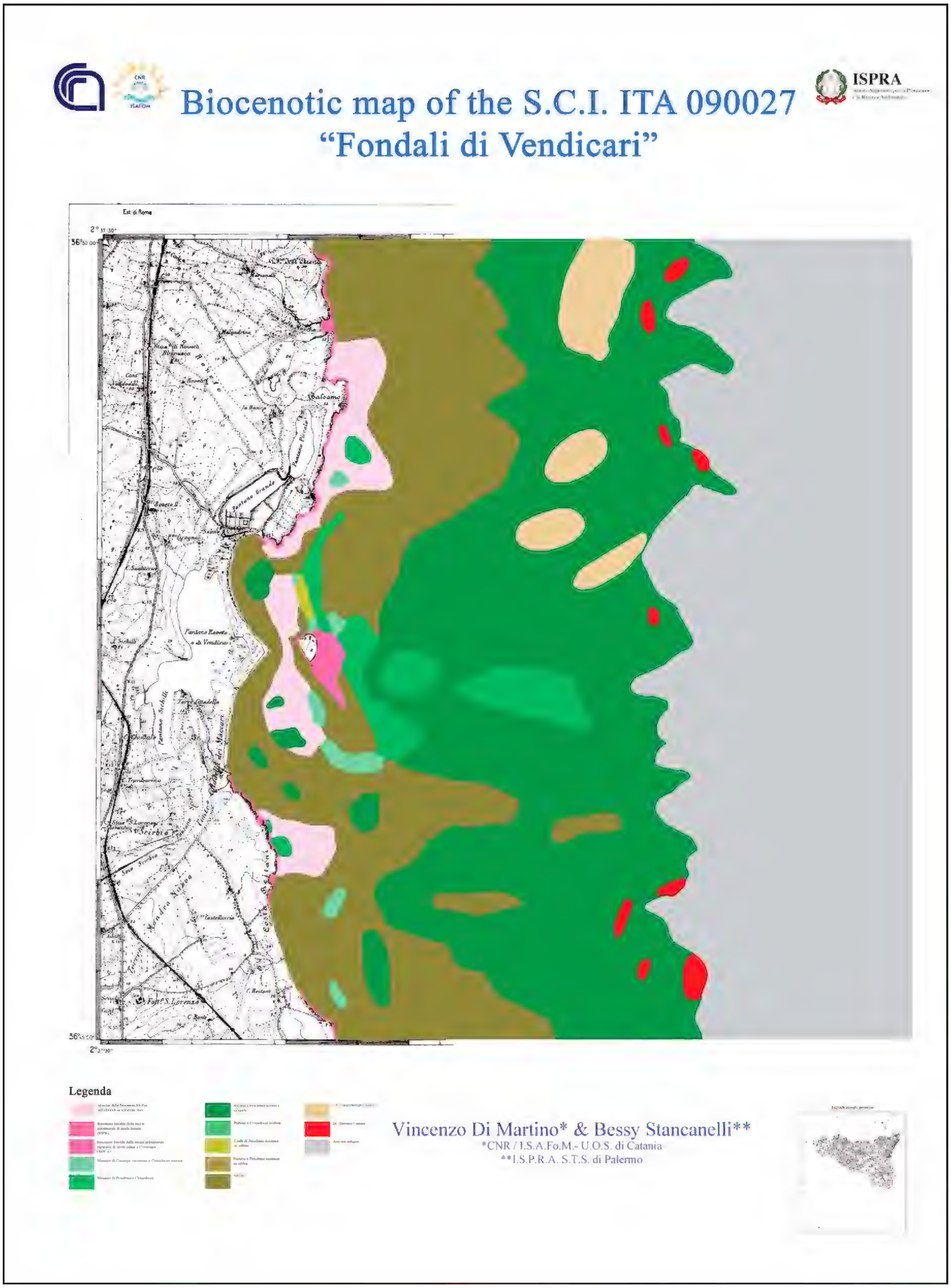
Biocenotic map of the S.C.I. ITA 090027
"Fondali di Vendicari"
ISPRA
Legenda
Vincenzo Di Martino* & Bessy Stancanelli**
*CNR / I.S.A.Fo.M.- U.O.S. di Catania
**I.S.P.R.A. S.T.S. di Palermo

Figure 1. Biocenotic map of the SCI ITA 090027 - Fondali di Vendicari.

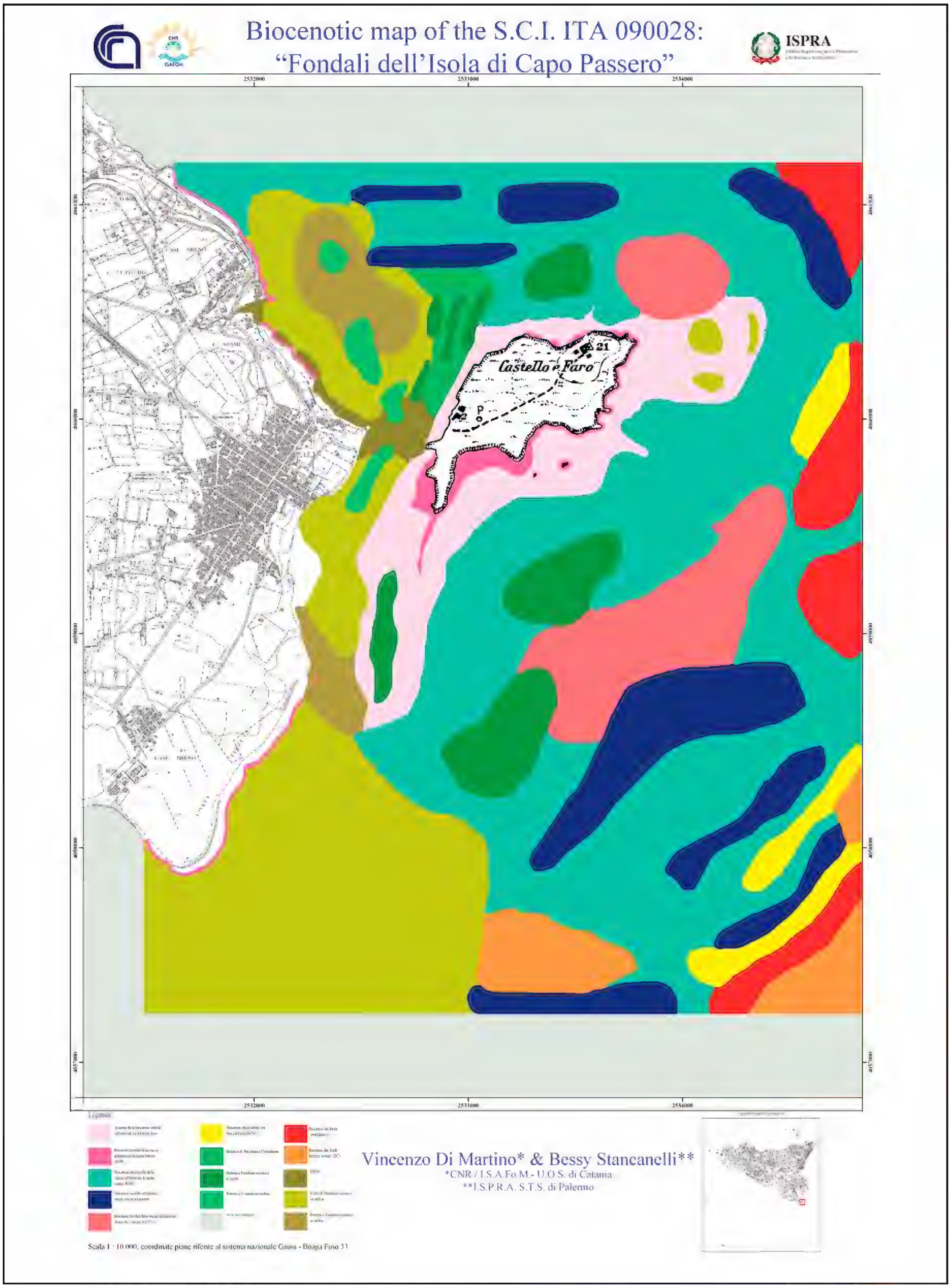
Biocenotic map of the S.C.I. ITA 090028:
"Fondali dell'Isola di Capo Passero"
ISPRA
Castello e Faro
21
Legenda
Vincenzo Di Martino* & Bessy Stancanelli**
*CNR / I.S.A.Fo.M.- U.O.S. di Catania
**I.S.P.R.A. S.T.S. di Palermo
Scala 1 : 10 000, coordinate piane riferite al sistema nazionale Gauss - Boaga Fuso 33

Figure 2. Biocenotic map of the S.C.I. ITA 090028 - Fondali dell'Isola di Capo Passero.

TAXA	ASPIM	HABITAT	BERN	BONN	CITES
MAGNOLIOPHYTA					
Cymodocea nodosa (Ucria) Ascherson			B1		
Posidonia oceanica (Linnaeus) Delile	P2		B1		
CHLOROPHYTA					
Caulerpa ollivieri Dostal	P2		B1		
HETEROKONTOPHYTA					
Cystoseira amentacea (C. Agardh) Bory var. *stricta* Montagne	P2		B1		
Cystoseira mediterranea Sauvageau	P2		B1		
RHODOPHYTA					
Lithophyllum byssoides (Lamarck) Foslie	P2		B1		
Ptilophora mediterranea (H. Huvé) Norris	P2		B1		
Schimmelmannia schousboei (J. Agardh) J. Agardh	P2		B1		
PORIFERA					
Aplysina aerophoba Schmidt, 1862	P2				
Ircinia foetida (Schmidt, 1862)	P2				
Sarcotragus (*Ircinia*) *pipetta* (Schmidt, 1868)	P2				
Spongia officinalis Linnaeus, 1759	P2		B3		
CNIDARIA					
Astroides calycularis (Pallas, 1766)	P2		B2		
BRYOZOA					
Hornera lichenoides (Linnaeus, 1758)	P2				
MOLLUSCA					
Charonia nodifera (Lamarck, 1822)	P2		B2		
Erosaria spurca (Linnaeus, 1758)	P2		B2		
Dendropoma petraeum (Monterosato, 1884)	P2		B2		
Gibbula sp.	P2		B2		
Lithophaga lithophaga (Linnaeus, 1758)	P2	H4	B2		
Luria lurida (Linnaeus, 1758)	P2		B2		
Mitra zonata Marryat, 1818	P2		B2		
Patella ferruginea Gmelin, 1791	P2	H4	B2		
Pinna nobilis (Linnaeus, 1758)	P2	H4			
Pinna rudis Linnaeus, 1758	P2				
Tonna galea (Linnaeus, 1758)	P2		B2		
Zonaria pyrum (Gmelin, 1791)	P2		B2		
CRUSTACEA					
Homarus gammarus (Linnaeus, 1758)	P3		B3		
Maja squinado (Herbst, 1788)	P3		B3		
Palinurus elephas (Fabricius, 1787)	P3		B3		
Scyllarides latus (Latreille, 1803)	P3	H5	B3		
Scyllarus arctus (Linnaeus, 1758)	P3		B3		
Scyllarus pygmaeus (Bate, 1888)	P3		B3		
ECHINODERMATA					
Ophidiaster ophidianus (Lamarck, 1816)	P2		B2		
Paracentrotus lividus (Lamarck, 1816)	P3				

TAXA	ASPIM	HABITAT	BERN	BONN	CITES
OSTEICHTHYES					
Epinephelus marginatus (Lowe, 1834)	P3				
Hippocampus hippocampus (Linnaeus, 1758)	P2				CD
Hippocampus ramulosus Leach, 1814	P2				CD
Pomatoschistus marmoratus (Risso, 1810)			B2		
Pomatoschistus tortonesei Miller, 1968	P2				
Syngnathus abaster Risso, 1826			B3		
Sciaena umbra Linnaeus, 1758	P3		B3		
REPTILIA					
Caretta caretta (Linnaeus, 1758)	P2	H2, H4	B2	D1	CA

Table 1. Protected species present in the study sites. Keys to abbreviations: B1 = BERN Ap. 1; B2 = BERN Ap.2; B3 = BERN Ap.3; D2 = BONN Ap.2; CA = CITES All. A; CB = CITES All. B; CD = CITES All. D; D1 = BONN Ap. 1; H2 = HABITAT Ap. 2; H4 = HABITAT Ap. 4; H5 = HABITAT Ap. 5; P2 = Annex II by ASPIM; P3 = Annex III by ASPIM.

by rocky outcrops a few meters from the sea surface. The northern limits of the area "A" is the location called "Eloro", which is the limit of the same S.C.I. "Fondali di Vendicari" while the southern boundary has been identified with the stretch of coast where there is the building known as "Torre Vendicari".

The sector "B" corresponds to the seabed in front to the long beach that characterizes the central portion of the site. This sector also includes the small island that rises a few meters above mean sea level.

The sector "C" corresponds to the stretch of rocky coastline that follows the beach and finishes with the southern border of the S.C.I. "Fondali di Vendicari".

In Table 1 are reported the high naturalistic value species found in this site.

In the seabed of the "S.C.I. ITA090027" were identified habitats of remarkable natural value of those listed in the document UNEP (OCA)/MEDWG.154/7,27 and also reported in Relini (2002). These are all included in the ASPIM Protocol of the Barcelona Convention and are, also, habitat considered relevant to the choice of sites at which to establish Marine Protected Areas.

In particular in the "A" sector was censused *Litophyllum byssoides* Assemblage Giaccone 1993, in the central area of the sector, assemblage with *Cystoseira amentacea* (C. Agardh) Bory var. *stricta* Montagne (as facies of *Cystoseiretum stricatea* Molinier, 1958) and *Posidonia oceanica* meadow (as *Posidonietum oceanicae* Molinier, 1958).

In the sector "B" seabottoms was censused trottoir at *Lithophyllum byssoides* (Lamark) Foslie (Giaccone, 1993), along the coast of the Isle of Vendicari, and *Posidonia oceanica* (Linnaeus) Delile meadow. While, in the seabottoms of "C" sector was censused assemblage with *Lithophyllum byssoides*, assemblage with *Cystoseira brachycarpa* J. Agardh emend. Giaccone var. *brachycarpa*, *Posidonia* meadow and two facies of the biocenoses of coral reefs: the facies at *Eunicella singularis* Esper, 1791 and the facies at *E. verrucosa* Pallas, 1766.

S.C.I. ITA090028 - Fondali dell'Isola di Capo Passero

In relation to the shape of the Capo Passero Island, it was decided to divide the perimeter of the island into two sectors. This division was made according to a hypothetical line oriented NE - SW, which ideally joins the northern tip and the southern tip of the island. On the basis of this assumption have been identified the two sectors. The area "A", which includes the coast of the island having western exposure and the sector "B" which includes the coast of the island having east facing. Also, have been investigated, as distinct, the two underwater caves present on the Capo Passero Island, the "Betsabea Cave" which opens along the coast of the sector "B" and "Enfasi Cave" located at the base of a small stack rock off the southern tip of the island.

The area "A" is placed along the side of the island less exposed to wave action because facing the Sicilian coast from here is just a few hundred meters. Under the "A" sector was made a further division into two sub-sectors "A1" and "A2". The subsector "A1" is characterized by lower gradient of depths and high geomorphological homogeneity. The sub-sector "A2", however, is characterized by coasts quite high that at some point take on characteristics of the cliff.

The sector "B" comprises the eastern and southeastern coasts of the island exposed to the open sea and, therefore, particularly susceptible to wave motion, that at certain times of the year is very intense. The coastline of this area of the island are characterized by a wide geomorphological variability both above and below sea level, showing a discrete heterogeneity of the populations living therein.

The sector "B" has been divided into a further two sub-sectors, "B1" and "B2". The first is characterized by high rocky shores, with characteristics of the cliff, and uneven along which there are a couple of deep inlets. The sub-sector "B2" is characterized by a trend of the coast line that describes two half moons separated by a small tip that stretches to a few tens of meters into the sea. Here the coast, always rocky, is low and heavily eroded by waves and atmospheric agents.

The species of high naturalistic value censused in the S.C.I. ITA 090028 are listed in Table 1.

Also in the "S.C.I. ITA090028" have been counted several habitats of high naturalistic value and all included in the list of Document UNEP (OCA)/MEDWG.154/7,27 and also reported in Relini (2002). All Habitats mentioned by experts as relevant to the choice of sites worthy of being identified as marine and coastal protected areas that could be included in the SPAMI list (Special Protected Areas of Mediterranean Importance).

In particular the habitats of high conservation interest, which have been recorded in the depths of this site are Association with *Lithophyllum byssoides*, *Posidonia oceanica* meadows, Association with *Sargassum vulgare* C. Agardh, Association with *Cystoseira compressa* (Esper) Gerloff et Nizamuddin f. *compressa*, Association with *Cystoseira amentacea* (C. Agardh) Bory v. *amentacea*, two Facies of the coralligenous biocoenoses: facies at *Eunicella singularis* and the facies at *E. verrucosa*, Biocenosis of mediolittoral caves and Caves and ducts in total darkness.

CONCLUSIONS

Research conducted during the course of this study has allowed an initial framework for the knowledge about the entire benthic component of the marine environment of Vendicari and Capo Passero Island (South Eastern Sicilian shoreline). These bottoms, in fact, though regarded by many of high conservation value and deserving of special protection measures, before this study, had never been investigated systematically and thoroughly. For this reason it's impossible to make a comparison with previous studies in order to analyze the changes of benthic assemblages over time.

Benthic cartography is a prerequisite for suitable planning and management of the marine environment; allocating human activities for reaching certain objectives should be based on correct knowledge of its structure, as well as its functions. The main goal of the newly developed Marine Strategy Framework Directive of the European Union is to achieve a good environmental status (GEnS) of the marine environment (Tunesi, 2012).

This study confirms the importance of the environment and the need to preserve these environments for the great richness of species and habitats of high naturalistic value. The authors, in fact, advance the hypothesis of safeguarding these two, "S.C.I." together with the other "S.C.I." marine life along the south-eastern coast of Sicily by the establishment of a "multi-spot" Marine Protected Area.

The proposed framework can improve the generation and dissemination of cartographic and visual data, and allow for management approaches based on scientific knowledge and EBM principles, taking into account stakeholders needs. This is in order to achieve a unique governance capable of managing organically all the natural emergencies present along the southeastern sicilian coastlines.

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MONOGRAPH

The endemic fauna of the sicilian islands

Calogero Muscarella[1] & Alessandro Baragona[2]

[1]Via D'Ondes Reggio 8/A Scala G, 90127 Palermo, Italy; e-mail: calogero@silenecoop.org
[2]Via Piersanti Mattarella 5, 90020, Sciara, Palermo, Italy; e-mail: alessandro.baragona@gmail.com

ABSTRACT

In this survey we propose an analysis of the endemic fauna (Mollusca, Arthropoda, Chordata) present in the 14 major circum-sicilian islands and in Lampione islet (Strait of Sicily, Pelagie Islands). Overall, 111 endemic taxa between species and subspecies have been identified. The largest taxonomical groups are Tenebrionid Beetles and Curculionids (respectively 18 and 16 taxa) and Gastropods (20 taxa), due to their strong inclination to insular differentiation, which is inversely proportional to their vagility. The number of endemic taxa per island is positively associated to the extent of the surface but not to the distance from the closest continental mass or altitude or geological origin. The most important connection is with the complex paleo-geographic history pertaining the different insular complexes.

KEY WORDS

Endemism; circum-sicilian islands; paleogeography.

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INTRODUCTION

Small islands and archipelagoes have always raised the interest of biologists, especially due to the peculiar flora and fauna which inhabits them (Pasta, 2008; Minelli, 2012). The Mediterranean is a sea basin gathering one of the largest insular groups in the world with approximately 5000 islands. This number raises up to approximately 11,879 if we consider the numerous minor islands as well (Blondel et al., 2010). The coastline of these islands extends for approximately 18,000 km, including 39% of all the Mediterranean coastal areas (cf. ANPA, 2001). The islands of the Mediterranean are, for the most part, strips of land above sea level which have latterly isolated themselves from the nearby continental masses. Other islands are of volcanic origin and have never had contacts with other lands. In the first case we speak about continental or "chersogenic" islands; in the second one, about "talassogenic islands" (see also Troia, 2012 and corresponding bibliography).

The organisms actively or passively colonizing the islands undergo a severe selective pressure triggered by both isolation and environmental characteristics; as an adaptative response, they develop more or less pronounced biological peculiarities, favouring the formation of endemic species (cf. Zunino & Zullini, 1995) (Figs. 1–4).

Several factors contribuite to the birth of these endemic species: paleogeography (a few have remained isolated for a long time, others have not), distance from the nearest continental mass (source area), size of the island (between a few square metres and 25,700 square km as is the case of Sicily, for instance), height above sea level, substrate, morphology. These factors, as a whole, have determined the high rates of endemism that have been observed in these islands (See ANPA, 2001). Endemic insular species are usually divided into two main categories: abandoned (paleoendemic species) or of new formation (neoendemic species). The first ones are formed by populations in ancient times common on ample areas, successively relegated in confined, separated areas detached from the original continental populations. On the contrary, neoendemic species are relatively recent taxa, appeared as a result of the colonisation of the islands in successive periods (Zunino & Zullini, 1995).

In this note we propose an analysis of the endemic fauna, known today, present in the circum-sicilian islands. Field and bibliographical research carried out have allowed us to identify as a whole 121 endemic taxa between species and subspecies (see Figs. 5, 6). The taxonomical status of certain entities, however, has not been confirmed by recent molecular analysis, or is nevertheless considered uncertain by several researchers; for this reason we have considered appropriate to exclude a few taxa, considering a total of 111 entities (see notes to Fig. 6). It is nevertheless an extremely important value considering that in Sicily, based on the data reported by Minelli et al. (2005), integrated by the contributions published until 2015 (Magrini et al., 2006; Aliquò et al., 2006; Magrini, 2007; Sparacio, 2007, 2014; Magrini et al., 2007; Magrini et al., 2008; Švihla, 2009; Arnone & Massa, 2010; Bonavita & Vigna Taglianti, 2010; Baviera, 2010; Baviera & Liberti, 2010; Baviera & Magnano, 2010; Hertach, 2011; Jordana et al., 2011; Kapp, 2010 ; Kleukers et al., 2010; Lo Cascio & Sparacio, 2010; Malicky, 2010; Magrini et al., 2010a; Magrini et al., 2010b; Rapuzzi & Sama, 2010; Stuben, 2010; Bellò & Baviera, 2011; Haitlinger, 2011, 2012; Magrini & Baviera, 2011; Magrini et al., 2011; Pagliano, 2011; Rigato, 2011; Colomba et al., 2012; Giannuzzi-Savelli et al., 2012; Liberto et al., 2012; Müller, 2012; Pantaleoni & Badano, 2012; Rapuzzi & Sparacio, 2012, 2015; Sabella et al., 2012; Gardini, 2013; Lourenço & Rossi, 2013; Magrini et al., 2013; Poggi & Baviera, 2013; Pellizzari, 2013; Arnone et al., 2014; Magrini & Paladini, 2014; Baviera, 2015; Colonnelli & Paladini, 2015; Magrini & Degiovanni, 2015; Magrini & Paladini, 2015; Magrini & Uliana, 2015) an overall of 850 endemic species are present, 13% of which is exclusive of the circum-sicilian islands.

Hints on the history of the faunistic exploration of circum-sicilian islands

Circum-sicilian islands have, over the centuries, been the destination of several scientific explorations, thanks to which a remarkable bulk of data has been gathered, which has constituted the basis for important contributions. For a detailed summary of the naturalistic exploration of Pelagie Islands and Pantelleria see Baccetti et al. (1995a); for the Aeolian Islands Lo Cascio & Navarra (2003). Particularly relevant has been the research coordinated by Edoardo Zavattari in 1950 in Linosa and Lampedusa islands, whose results have flowed for the most part in the volume “Biogeografia delle isole Pelagie” (Zavattari, 1960), still considered a landmark for the study of biogeography of the circum-sicilian islands (Baccetti et al., 1995b). In particular, Zavattari and his partners found 415 species of insects in the two islands. For Pantelleria a significant push to entomological research has been given by the Museo Civico di Storia Naturale of Venice with three different gathering campaigns led between 1983 and 1986, followed by a number of contributions published by the Museo itself (see Ratti, 1986). Particularly important, between the seventies and the nineties, was the research carried out jointly by Palermo University and “Consiglio nazionale delle Ricerche”. The results to this survey have constituted the basis to the monograph “Arthropoda di Lampedusa, Linosa e Pantelleria”, reporting a whole of 1718 species of arthropods (Lo Valvo & Massa, 1995). In particular, to the known 855 species, another 863 (several of which were new for science) are added to the checklists reported in the volume. This work makes the explorative level of the three islands satisfactory as a whole, even though not thorough, also due to the fact that in the sole Lampedusa island, between 1995 and 2012, another 71 species have been cited (Goggi, 2004; Li Causi et al., 2013). Between 1994 and today, 4 new species have been described for Pantelleria (*Pseudomeira cossyrica* Pierotti et Bellò, 1994; *Probaticus cossyrensis* Sparacio, 2007; *Echinodera diottii* Stuben, 2010; *Pseudoapterogyna euphytus lamantiai* Sparacio, 2014), 4 for Lampedusa (*Torneuma clandestinum* Magnano et Mifsud, 2001; *Torneuma extinguendum* Magnano et Mifsud, 2001; *Physetopoda silviae* Pagliano, 2011; *Neumatora annamariae* Magrini, Abbazzi et Petrioli,

Island	acronym	Area (km^2)	Origin	Geographic coordinates	m.s.l.m.	Distance to mainland (km)	Endemic and subendemic taxa	Number of taxa for km^2
Eolie Stromboli	ST	12.2	Volcanic	Lat: 38.80° N; Long: 15.25° E	924	54	11	0.9
Panarea	PA	3.4	Volcanic	Lat: 38.63° N; Long: 15.07° E	420	41	10	2.94
Vulcano	VU	21	Volcanic	Lat: 38.42° N; Long: 14.98° E	499	20	12	0.57
Lipari	LI	37.3	Volcanic	Lat: 38.45° N; Long: 14.97° E	602	27	14	0.38
Salina	SA	26.4	Volcanic	Lat: 38.57° N; Long: 14.87° E	962	38	17	0.64
Filicudi	FI	9.5	Volcanic	Lat: 38.58° N; Long: 14.58° E	773	45	10	1.05
Alicudi	AL	5.1	Volcanic	Lat: 38.55° N; Long: 14.37° E	675	53	6	1.18
Ustica	US	8.1	Volcanic	Lat: 38.72° N; Long: 13.20° E	266	51	4	0.49
Egadi Levanzo	LE	5.6	Sedimentary	Lat: 37.59° N; Long: 12.20° E	278	13	6	1.07
Favignana	FA	19.5	Sedimentary	Lat: 37. 55° N; Long:12.19° E	302	8	6	0.25
Marettimo	MA	12.3	Sedimentary	Lat: 37°58° N; Long: 12.3° E	686	35	18	1.46
Pantelleria	PN	83	Volcanic	Lat: 36.80° N; Long: 12.00° E	836	67	20	0.24
Pelagie Linosa	LN	5.4	Volcanic	Lat: 35.88° N; Long: 12.38° E	195	165	7	1.29
Lampione	LA	0.036	Sedimentary	Lat: 35.57° N; Long: 12.33° E	36	100	9	250
Lampedusa	LM	20	Sedimentary	Lat: 35.52° N; Long: 12.62° E	133	120	27	1.35

Table 1. Geographic coordinates of the circum-Sicilian islands, number of known endemic taxa and density.

2013) and 1 for Lampione (*Otiorhynchus* (*Arammichnus*) *poggii* Di Marco, Osella et Zuppa, 2002).

We also have a good overall level of the faunistic knowledge for the Aeolian Archipelago and for the Island of Ustica, systematically investigated especially from the sixties with the project "Piccole Isole" promoted by CNR (Lo Cascio & Navarra, 2003). The conspicuous material gathered has been published in the conference proceedings to the "XVIII Convegno della Società Italiana di Biogeografia", whose subject was "The animal and vegetal population of circum-sicilian islands" (AA.VV., 1973). In recent times several contributions have updated the knowledge on many Aeolian populations of invertebrates (Gridelli, 1972; Ratti, 1987; Aliquò 1993, 1995; Lo Cascio & Magrini, 1998; Cecchi & Lo Cascio, 1999, 2000; Cecchi et al., 1999; Arnone et al., 2001; Dapporto & Lo Cascio, 2001; Lo Cascio et al., 2006) and vertebrates (Lo Cascio, 1994, 2000, 2009, 2010; Deidun et al., 2011; Lo Cascio et al., 2001, 2005; Scalera et al., 2004) as well as the discovery of a few new species (*Pseudomeira aeolica* Bellò, Pesarini et Pierotti, 1997; *Ocys beatricis* Magrini, Cecchi et Lo Cascio, 2000; *Nalassus pastai* Aliquò, Leo et Lo Cascio, 2006; *Anthaxia* (*Haplantaxia*) *flaviae* Lo Cascio et Sparacio, 2010; *Firminus massai* Arnone, Lo Cascio et Grita, 2014).

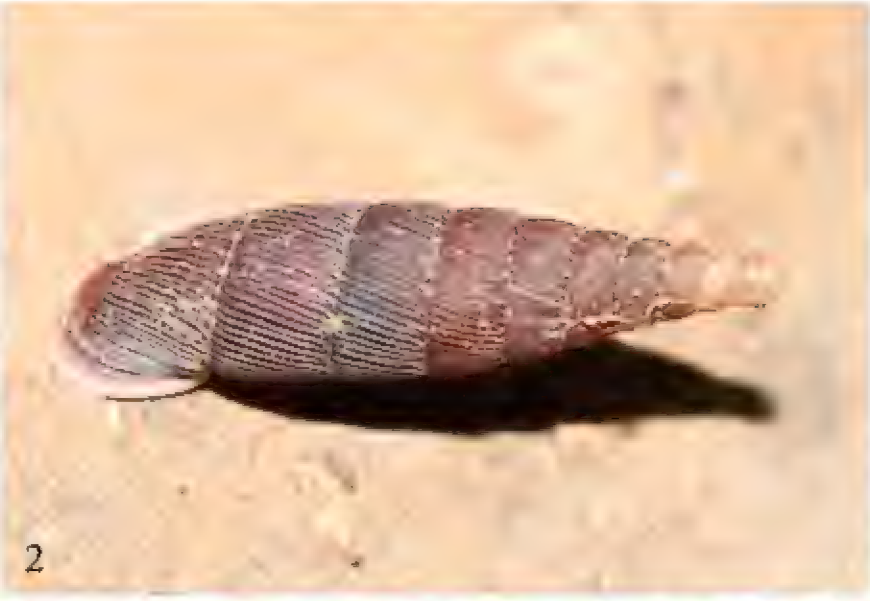
Differently from the other circum-sicilian islands, the Egadi islands have been the subject for deeper zoological surveys only starting from the end of the sixties; these surveys have been carried out by CNR (project "Piccole Isole") (Reverberi & Riggio, 1971). The results to these surveys have mainly pertained some groups of invertebrates (Matic, 1968; Focarile, 1969; Strasser, 1969; Marcuzzi, 1970; Magistretti, 1971; Alicata, 1973; Caruso, 1973; Tamanini, 1973), Amphibians and Rectiles (Bruno, 1970; Lanza, 1973). From that moment until today other contributions have been added, which favoured a widening of the available knowledge, particularly for tenebrionid beetles (Aliquò, 1993, 1995) and terrestrial molluscs (Beckmann, 1992; 2003; Cianfanelli et al., 2004;

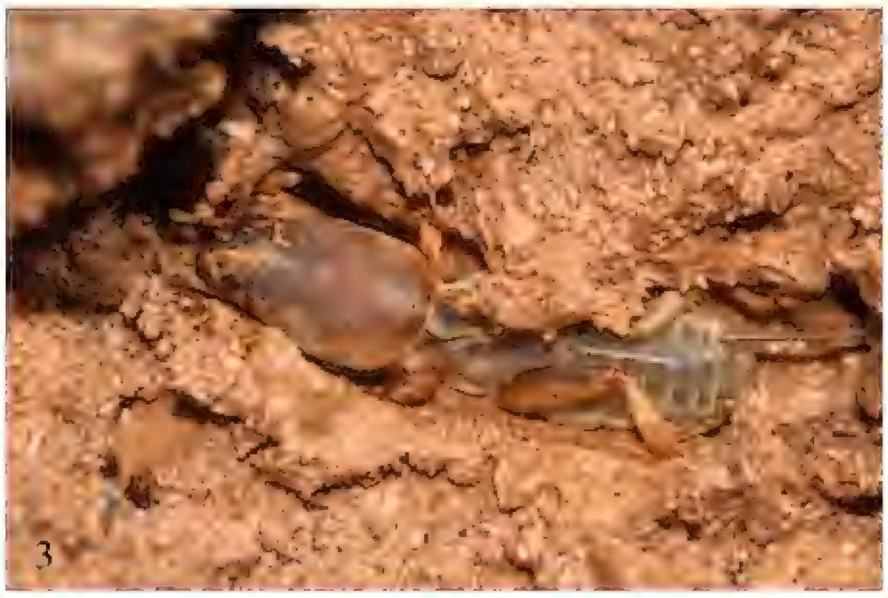
Fiorentino et al., 2010; Manganelli et al., 2007; Liberto et al., 2012; 2015), as well as the description of some interesting endemic species (the ortopheran *Acinipe galvagnii* Cusimano et Massa, 1977; the coleoptera *Otiorhynchus* (*Arammichnus*) *aegatensis* Magnano, 1992; *Typhloreicheia* (*Typhloreicheia*) *berninii* Magrini, Bastianini et Petrioli, 2003; *Malthinus egadiensis* Švihla, 2009; *Alaocyba ientilei* Baviera, 2010; *Danacea* (*Danacea*) *hierena* Baviera et Liberti, 2010; *Entomoculia hieratica* Poggi et Baviera, 2013; the Phasmatodeo *Bacillus grandii maretimi* Scali et Mantovani, 1990; the mollusc *Schileykiella bodoni* Cianfanelli, Manganelli et Giusti, 2004.

MATERIAL AND METHODS

Geographical placement

The circum-sicilian islands are a totality of 105 (between major islands, islets, rocks and sea stacks) detected by the Sicilian Island Award (S.I.A.) as valid islands (Islands acknowledged by IOTA regulation -www.dxawards.com/Lists/sicilianisawd.htm [accessed 24 Agosto 2015]) which as a whole constitute approximately 1.11% of all the regional surface (about 285.4 km² on a total of 25,711 km²). For the most part they are rocks or islets, generally of scarce naturalistic interest and perimetral to the major islands. In this analysis the 14 biggest islands have been taken into consideration (Stromboli, Panarea, Vulcano, Lipari, Salina, Filicudi, Alicudi, Favignana, Levanzo, Marettimo, Ustica, Pantelleria, Lampedusa, Linosa) and the islet of Lampione, while the Maltese Archipelago has been excluded as administratively not bond to Sicily. These islands can be gathered into three main archipelagoes: the Aeolian Islands (Volcanic), the Egadi (Sedimentary), the Pelagie Islands (both volcanic and sedimentary); the remaining two islands, Ustica and Pantelleria (both volcanic) are rather isolated (see Fig. 5). All of these islands are characterized by an ample latitudinal extension, running





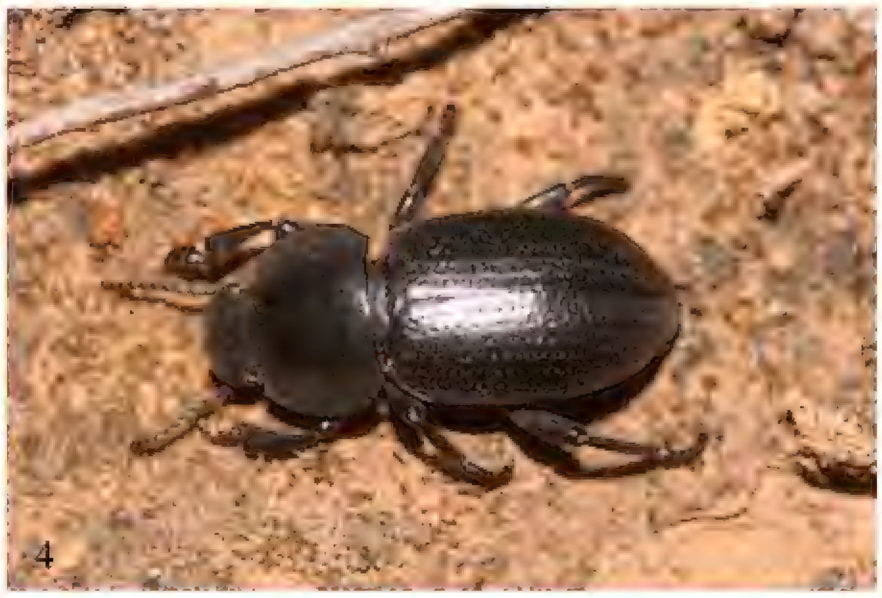


Figure 1. *Acinipe galvagnii* from Marettimo; Figure 2. *Siciliaria scarificata* from Marettimo.
Figura 3. *Gryllotalpa cossyrensis* from Pantelleria. Figure 4. *Heliopates avarus donatellae* from Pantelleria.

from 35° 30'N of Lampedusa, in Pelagie islands, to the 38° 50'N of Strombolicchio, in the Aeolian archipelago. The strait of Messina (approximately 3 km of length in the narrowest point) currently separates Sicily from Eurasia, while the portion which is closest to the African Continent (Tunisia), is about 70 km distant from the island of Pantelleria.

Data gathering and elaboration

To propose a thorough summary we have analyzed the ample bibliography available today on the circum-sicilian islands. In particular, we have made reference to the works included in Zavattari (1960), Francini Corti & Lanza (1973), Massa (1995a), Sparacio (1995, 1997, 1999), to the management plans of the natura 2000 sites "Isole Egadi", "Isole Eolie", "Isole Pelagie", "Isola Di Ustica", "Pantelleria" (AAVV, 2009a, b, c, d), as well as to the dossiers of the checklist of Fauna d'Italia (Minelli et al., 1993–1995) and to the exquisite though incomplete Ckmap 5.4.1 (Stoch, 2006) (for the list of the refence from which the taxa distribution has been drawn, see Fig. 6). As long as possible, we have consulted the original description of the considered species bearing in mind the successive chronological, taxonomical and nomenclatural updates. The reference nomenclature follows the checklist of Fauna d'Italia (Minelli et al., 1993–1995), updated case by case. We have attempted to sum up data related to all the metazoans. However, only advisory of endemic species referable to Arthropoda, Mollusca and Chordata have been taken into consideration. Research related to other groups are now partial and incomplete. Some species present exclusively in the small islets that are perimetral to the major island have been included among these last ones. In particular, *Anaspis akaira*, known solely for the Conigli islet, has been included among the species of Lampedusa; *Passalozetes paucesculptus*, known for Basiluzzo, among the ones of Panarea. The data has been organised in a database created in a Microsoft Access 2007 environment, and elaborated with Microsoft Excel 2007.

DISCUSSION

All the insular population, as effectively isolated, may show more or less pronounced characteristics which, in time, may lead to the formation of endemic taxa. It is a complex process, influenced by a multiplicity of factors, above all taxa vagility and paleogeographic evolution of the islands. (Whittaker, 1998). Generally, since the a drop in the dispersive capacities raises the possibilities of genetic isolation, groups of animals with scarce dispersive capacities show higher levels of endemism in confrontation with others with higher dispersive capacity (Minelli et al., 2005).

By observing figure 5, as a confirmation to this hypothesis, we can observe the absence of Diptera, Odonata, Neuroptera and generally of groups characterized by a marked vagility among the 111 endemic taxa of the fauna of circum-sicilian islands. Well represented are the Gastropod Molluscs (20 taxa, 18%), whose scarce dispersive capacity is well-known. As it is legitimate to expect, of the 111 taxa taken into consideration, about 50% is made up by Coleoptera, by far the most ecologically diversified group on a global level, constituting alone over 20% of Italian fauna (Ruffo & Stoch, 2005). Among Coleoptera, as in figure 6, the largest families are made up by Tenebrionids (18 taxa, 33%) and Curculionids (16 taxa, 30%), two groups characterised by a strong tendency to insular differentiation (Massa, 1995b).

The level of endemism in insular populations, furthermore, is positively correlated to surface, habitat diversity, age and distance of the island from the continent (Whittaker, 1998).

To verify how much these factors influence the endemic contingents in the circum-sicilian islands, the number of endemic taxa of every island has been correlated to

1) the distance from the nearest continental mass (Sicily/Northern Africa)

2) maximum height (indirect index of habitat diversity)

3) surface. On the basis of the variable as in figure 6, a regression has been carried out, using the Pearson index of correlation. From the results obtained, we observe that neither the distance from the continent (r = 0.198) nor height (r = 0.235) are correlated to the number of endemic taxa (the Pearson coefficient "r" is a measure of the correlation between the two viariables: it can variate between +1 or -1 and it acquires these extreme levels if the correlation - positive or negative - is perfect, while it acquires values close to zero if the two variables are independent). A weak correlation has emerged

by relating the number of endemic species with the area of the islands (Linear function model data: $y = 0.1608x + 8.9845$; $R = 0.3209$; Pearson correlation index $r = 0.54$, see figure 8).

Also, no relations seem to exist between the number of endemic species and the geological structure of the islands (volcanic or sedimentary). Alicudi and Favignana, for instance, show the same number of endemic taxa (6) but they are characterised by a profoundly different lithology (see figure 6).

The complex paleogeographic history (see further on) of the circum-sicilian islands, together with the dispersive features typical of every taxa, seem to have been the most incisive factors determining the endemic population, and it does not seem possible to hypothesize a unique colonisation and speciation model. Quite certainly, the different islands (or at least the different archipelagoes), have had different population means, whose vicariantist and dispersalist models overlap.

Considerations on the endemic populations and paleogeography of the circum-sicilian islands

Aeolian Archipelago

The Aeolian Islands are of relatively recent formation: the most reliable radiometric dating estimate that the archipelago formed approximately 1.3 million years ago (in reference to the disappeared apparatuses), while the most ancient rocks above sea level, present in Filicudi, date back to about 600,000 years ago (De Rosa et al., 2004; Lucchi et al., 2013). They are separate from Sicily by a sea area which is up to 2000 m. deep and have always been isolated, even during the marine regressions in Pleistocene. Considering the relatively young age of the archipelago, the high number of endemic species found today (30) and its relative faunistic richness are surprising (cf. Lo Cascio & Navarra, 2003). Based on this interpretative model, the entire Aeolian fauna should be of recent acquisition as entirely formed by propagules of high vagility species which rapidly differentiated on the spot thanks to the well known phenomena of the "bottleneck" and the "founder effect". We should as well consider that during the phases of marine regression the distance between Sicily and these islands was undoubtedly shorter (though not annulled due to the sea depth in this coastal area), so that even the colonization of scarcely vagile insects, as the Tenebrionids, was made easier in these periods (Fattorini, 2001). This way, species belonging to groups with a high tendency to speciation have had the possibility to reach the Aeolian islands and rapidly differentiate (Fattorini, 2011). This might be the case of the disderid spiders, present in Lipari with two endemic taxa - *Harpactea aeoliensis* Alicata, 1973 and *Dysdera flagellifera aeoliensis* Alicata, 1973 (Alicata, 1973); of the Curculionid Beetles *Otiorhynchus* (*Arammichnus*) *meligunensis* Magnano, 1992 and *Pseudomeira aeolica* Bellò, Pesarini et Pierotti, 1997; of the Blattaria, present with three exclusive species (*Ectobius aeoliensis* Failla et Messina, 1974, *E. filicensis* Failla et Messina, 1974 ed *E. parvosacculatus* Failla et Messina, 1974) or of the gastropods of the *Oxychilus* type Fitzinger, 1833, *O.* (*Hyalocornea*) *alicurensis* (Benoit, 1857) of Alicudi and *O.* (*Oxychilus*) *lagrecai* Giusti, 1973 of Filicudi. A likely hypothesis to explain the genesis of some endemic species reconnects to the high degree of environmental instability typical of the Aeolian islands: continuous eruptions allegedly determined the nullification of the present fauna, repeatedly causing "bottleneck" effects, triggering and quickening the birth of many of the endemic species present on these islands (Lo Cascio & Navarra, 2003; Fattorini, 2009; Lo Cascio & Sparacio, 2010). This might as well be the origin of some taxa such as *Anoxia* (*Mesanoxia*) *matutinalis moltonii* Sabatinelli, 1976, exclusive of Vulcano but present with the nominal subspecies in the nearby Lipari and Salina, *Anthaxia* (*Haplantaxia*) *flaviae* Lo Cascio et Sparacio, 2010 known for Panarea, Salina and Lipari but sympatric in the latter with the akin *A.* (*Haplantaxia*) *scutellaris* Genè, 1839 probably for a process of "double invasion" (Lo Cascio & Sparacio, 2010) and especially the Lacertid *Podarcis raffoneae* (Mertens, 1952) and its subspecies. In particular, for *P. raffoneae*, it would be otherwise difficult to explain the supposed "antiquity", considering that the molecular clocks that have been used for the datations confer it an age between 2 and 13 million years, well before the formation of the "present" Aeolian islands (see Lo Cascio & Navarra, 2003). Its current distribution, limited to a few peripheral islets and Vulcano, is interpreted as relictual in the field of an original area which probably involved the whole archipelago; the most part of the populations have allegedly faced local extinctions as a result of the processes of competitive exclusion derived by the colonisation of the archipelago by the lizard *P. siculus* (Rafinesque-Schmaltz, 1814) (Lo Cascio, 2010).

However, to the antique datation of the molecular clock for *P. raffoneae* we need to add the difficulty to explain the presence of terrestrial molluscs with high preference for calcium. Among these ones *Hypnophila incerta* (Bourguignat, 1858), present in many of these islands, *Oxychilus* (*Hyalocornea*) *alicurensis* of Alicudi and *O.* (*Oxychilus*) *lagrecai* of Filicudi. As such, the genesis of Hygromiidae *Helicotricha carusoi* Giusti, Manganelli et Crisci, 1992, is hard to interpret as it belongs to a genus that is endemic of the Aeolian and implies a very long time for its differentiation.

Giusti (1973) hypothesizes the existence of ancient groups of territories above sea level which left groups of paleo-endemic species to the new Aelioan islands of formation. These territories might have been situated further north, and even derived by the fault of Tyrrhenian microplates in their shift towards their present position, or further south, in contact with the Sicilian coast line.

A different biogeographical explanation was proposed for *Ocys beatricis* Magrini, Cecchi et Lo Cascio, 2000: a small carabid, endemic in Lipari and rather isolated in the field of its genus and only akin to another specie, *Ocys inguscioi* Magrini et Vanni, 1992, localised in southern Puglia. Considered that these are winged species, potentially capable of highly dispersive capacities, it is possible to suppose a climate or ecological change to have caused the disappearance in the original distribution area of a common hypothetical ancestor, and the distance between the surviving population to have triggered a differentiation on a species level (Magrini et al., 2000; Lo Cascio & Navarra, 2003). The endemic sub species of garden dormouse present in Lipari, *Eliomys quercinus liparensis* Kahamann, 1960, differentiated, according to several authors (see Angelici et al., 2009) starting from nuclei originally introduced in the Roman age for dietary.

Egadi Archipelago

The three major islands of the Egadi are of sedimentary origin, different from the geological and paleogeographic history. Favignana and Levanzo are, as a matter of fact, a fragment of Sicily, to which they alternately remained connected during the eustatic variation in Pleistocene, and from which they are separated by a sea bed only 40 m. deep (Ruggieri, 1973; Agnesi et al., 1993), the last time durind Würmian glaciation (until about 12,000 years ago) (Massa, 1973; Ruggieri, 1973). On the contrary, Marettimo originated almost exclusively from Triassic sediments that show no similarities to the Sicilian territory as they are correlated to surfacing present in northern Africa and Iberian Peninsula (Ruggieri, 1973). Furthermore, it is separated from the two other islands by a channel ("Marettimo Channel") whose maximum depth is 350 m, enough to prevent connections with the Sicilian territory during Pleistocenic regressions (Agnesi et al., 1993). These pronounced differences also reflect, as it is right to expect, on faunistic populations of the three islands. Marettimo, as pointed out by several authors (Alicata, 1973; Bordoni, 1973; Caruso, 1973; Lanza, 1973; Magnano & Osella, 1973), is characterized by a pre-quaternary population with predominant similarities with the western Mediterranean. Favignana and Levanzo show poorer endemic populations and generally with Sicilian affinities (Canzoneri, 1968). As a whole, 20 endemic entities are known in the archipelago, 18 of which are present in Marettimo alone. Levanzo has scarcer endemic contingents (6 taxa, only one of which - gastropod *Rupestrella rupestris coloba* (Pilsbry, 1918) - exclusive of the island) and Favignana (6 taxa, all in common with the other islands of the archipelago). Two endemic vertebrates are present - the Soricid *Crocidura sicula aegatensis* Hutterer, 1991, present in all of the three islands, and the lacertid *Podarcis waglerianus marettimensis* (Klemmer, 1956) in Marettimo alone - whose taxonomic status, besides, is considered rather doubtful (Capula, 1994; Sarà, 1995). Invertebrates make up the largest endemic element under the biogeographical profile. In the field of the endemic fauna of Marettimo we need to highlight the presence of interesting paleoendemic species, such as the underground Coleoptera *Typhloreicheia* (*Typhloreicheia*) *berninii* Magrini, Bastianini et Petrioli, 2003 and *Alaocyba ientilei* Baviera, 2010; the Gastropods *Oxychilus* (*Hyalofusca*) *denatale* (Pfeiffer, 1856), *Siciliaria scarificata* (Pfeiffer, 1856), *Marmorana insularis* (Benoit, 1857) and *Schileykiella bodoni* Cianfanelli, Manganelli et Giusti, 2004; the Tenebrionid

Coleoptera *Odocnemis ruffoi ruffoi* (Canzoneri, 1970). This last species belongs to a sub family of Tenebrionidae, the Elopinae, which in the Mediterranean area enumerate several elements with a circumscribed geonemy and numerous endemic species. *Odocnemis ruffoi* has an exclusively insular Tyrrhenian distribution: nominal form is found in Marettimo, while another subspecies (ssp. *osellai* Gardini, 1979) was described for the Island of Montecristo, in the Tuscan Archipelago. This fact, together with the peculiar, systematic position of the species, inspires the hypothesis of an area of relictual distribution, which might have shrunk in comparison to the original one for unspecified (maybe ecological) reasons. Both the islands were allegedly refuge-posts for *O. ruffoi*, while the isolation might have determined a successive differentiation in the two sub-specific forms presently known (AA.VV. 2009a; Aliquò & Soldati, 2010). The case of *Allophylax costatipennis godenigoi* Canzoneri, 1970 is different. The species has a northern-african type of distribution and it is present on the island of Lampedusa (see Aliquò& Soldati, 2010) while it seems to be lacking in Sicily. The differentiation of the population of Marettimo at an infraspecific level seems to be due to its geographical isolation in comparison to the ones of the rest of the area of distribution of the species (AA.VV., 2009a). Other important paleoendemic species of Marettimo are the Isopod Crustaceans *Bathytropa ruffoi* Caruso, 1973 and *Spelaeoniscus lagrecai* Caruso, 1973. The genus *Bathytropa* Budde-Lund, 1885 encompasses 8 species diffused in different point areas in the Mediterranean water basin: a distribution which, according to Caruso (1973), suggests a pre-Pliocenic origin. To the hypothetical fragmentation of the Tyrrhenid of the tertiary period is to be connected the origin of Spelaeoniscidae *Racovitza*, 1907 (Caruso, 1973), a family present, for Italy in the sole Sicily with 5 endemic species, 3 of which in the circum-sicilian islands (Argano et al., 1995; Caruso & Lombardo, 1995). Other entities which are exclusive of the archipelago belong to genera which are rich in point-schizo-endemic species, such as the Coleoptera *Otiorhynchus* (*Arammichnus*) *aegatensis* Magnano, 1992 (present in all of the three islands), *Entomoculia hieratica* Poggi et Baviera, 2013 (Marettimo), the Chrysomelidae Coleoptera *Pachybrachis osellai* Daccordi et Ruffo, 1975 (present in Levanzo and Marettimo). The apparently disassociated distribution of the Issid Homoptera *Conosimus malfanus* Dlabola, 1987, until now known only for Marettimo and Salina. A future deeper look of the research might reveal the presence of this species also alongside the northern Sicilian coastlines.

Island of Ustica

The Island of Ustica, as the Aeolian Island, is a talassogenic island. It is the highest tip of a vast undersea volcanic apparatus, whose base is over 2000 meters below the sea level. The intense volcanic explosive activity that took place starting from Pliocene is accountable for the continuous accumulation of igneous and pyroclastic material on the sea bed which, in medium Pleistocene (approximately 350 million years ago) led to the emersion of the island (AA.VV., 2009a; Bonomo & Ricci, 2010). Ustica is separated from Sicily by a wide and deep sea area and it has probably always remained isolated, even during pleistocenic regressions. The young geological age of Ustica, together with its isolation, are the main conditions making its faunistic populations (prevalently of a Sicilian or southern Italian type) not particularly relevant. (cf. Francino Corti & Lanza, 1973). Only 5 endemic species, probably all of new formation, are pointed out for the island. The most interesting element is the Cave Isopod *Spelaeoniscus vandeli* Caruso, 1974, apparently well differentiated by the congeneric species (Caruso & Lombardo, 1995). Interesting is the presence of *Oxychilus* (*Hyalocornea*) *nortoni* (Calcara, 1843), a specie belonging to the subgenus *Hyalocornea* Monterosato, 1892, in a particolar distribution with *O.* (*H.*) *alicurensis* typical of Alicudi, *O.* (*H.*) *canini* (Benoit, 1843) of north-western Sicily, *O.* (*H.*) *egadiensis* Riedel, 1973 of Favignana and Levanzo and probably also *O.* (*H.*?) *pomelianus* Bourguignat, 1867 of NW-Algeria and the Galite Island in Tunisia (Riedel, 1980). The Blattaria *Ectobius usticaensis* Failla et Messina, 1974, according to Failla et al. (1973) and Failla & Messina (1974) who minutely studied the anatomy of the glandular dimples, allegedly belongs to a different evolutionary line if compared to *Ectobius* Stephens, 1835 Sicilian and Aeolian. *Opatrum* (*Colpophorus*) *validum marcuzzii* Canzoneri, 1972 is part of a Northern African chorotype present, other than in insular Sicily with the nominal subspecies, in the islet of Lampione (ssp. *rottembergi* Canzoneri, 1972) and in Tunisia, Pantelleria and Sardegna (ssp. *schlicki* Gebien, 1906).

Pelagie Islands

The Pelagie Islands are connected to each other only from a geographical (and not geological) point of view. Lampedusa and Lampione are two continental carbonate (Agnesi & Federico, 1995). Differently, Linosa formed between one million and 500,000 years ago during three different stages of volcanic activity (see Tranne, 2002). The difference in their birth reflects also on the size of their populations and on the level of endemism. While Linosa has only 8 endemic species, Lampedusa has 25; 9 are found on Lampione. Lampedusa and Lampione are the last emerged outpost of the African plate and until the last glaciation they have been connected to continental Africa. They therefore own a rich amount of species revolving around northern Africa, arrived via land during this period which, with the sea level rise, have successively remained trapped in the two islands. Here they have undergone more or less marked speciations. Linosa, moreover, has never had contact with other land, therefore the origin of its population is to be searched only on active or passive colonisations that happened during some hundreds of thousands of years. This partially explains the scarcity of species in Linosa in confrontation to Lampedusa (1021 species, between Molluscs e Arthropods, were found in Lampedusa, only 349 in Linosa: AA.VV., 2009d). This faunistic poverty is attributable not only to the different origin of the islands, but also to their different extension (Lampedusa is 20.2

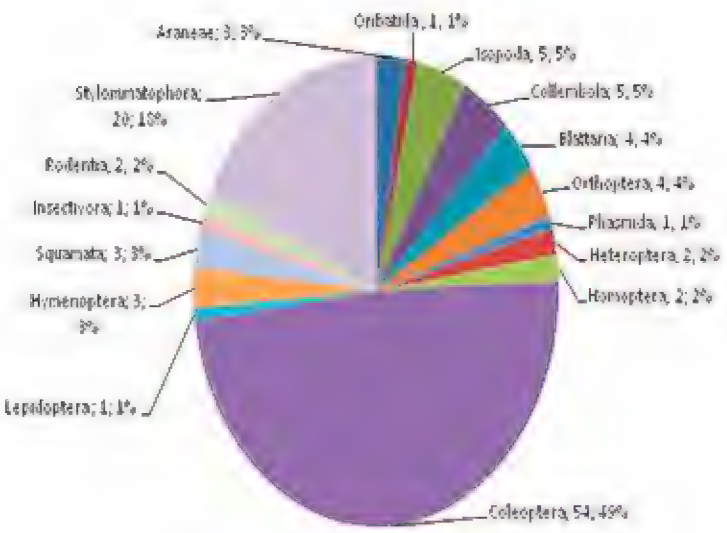


Figure 5. Number of endemic taxa per island. Some taxa are present in more than one island.

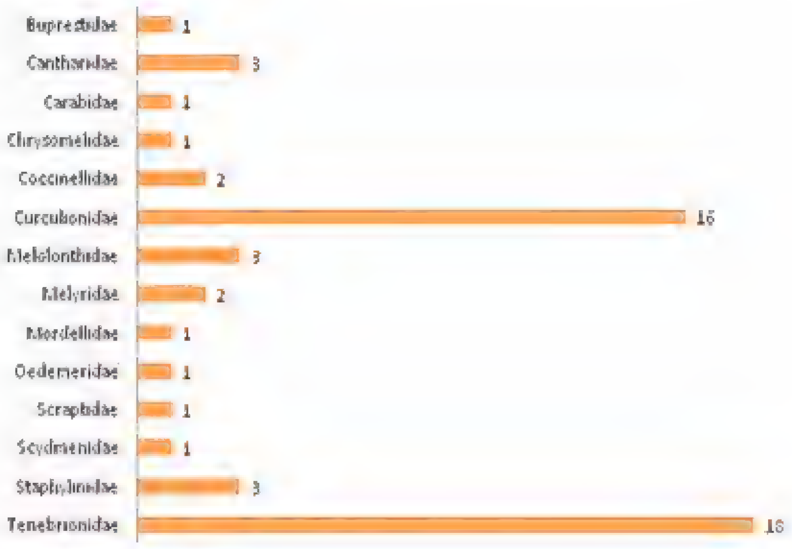


Figura 6. Number of endemic species per Coleoptera family

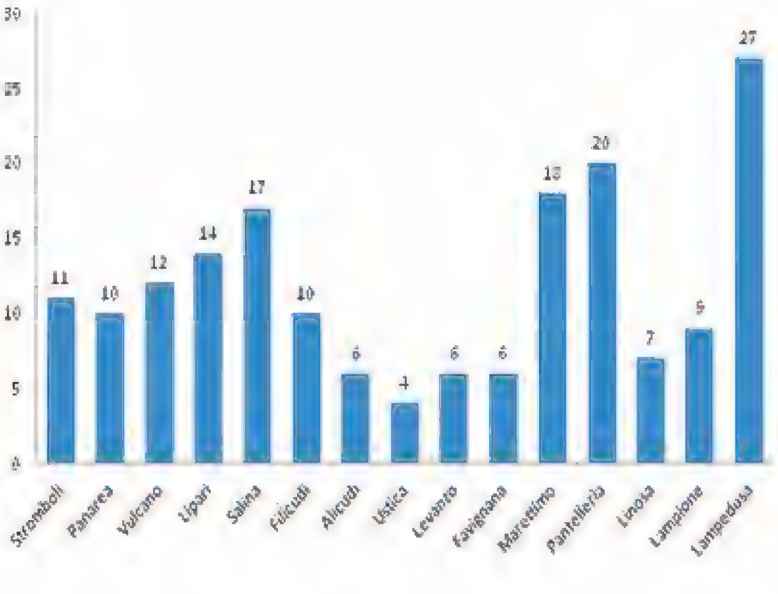


Figure 7. Number of endemic taxa per island. Some taxa are present in more than one island.

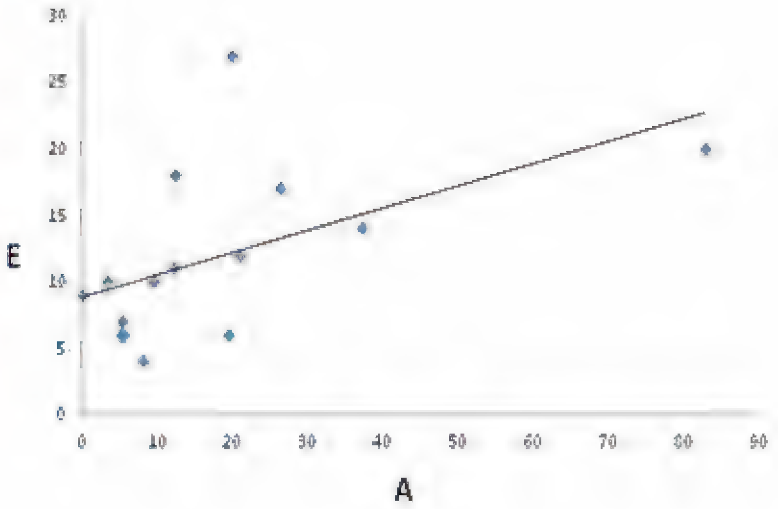


Figure 8. Regression curve for the relationship Island area in km^2 (A)-number of endemic taxa present (E) (see text).

square km wide, while Linosa is only 5.43) whose calcareous nature seems to offer higher colonization possibilities to several species of Arthropods (Massa, 1995b) and land Molluscs. This last point is evident if we consider that on 5 endemic taxa present on the Italian island in the Strait of Sicily - *Lampedusa lopadusae lopadusae (*Calcara, 1846) [Lampedusa], *L. lopadusae nodulosa* Monterosato, 1892 [Lampione], *Oxychilus* (*Oxychilus*) *diductus* (Westerlund, 1886) [Lampedusa], *Trochoidea cumiae* (Calcara, 1847) [Lampedusa and Linosa], *Cernuella metabola* (Westerlund, 1889) [Lampedusa] - none is present in Linosa and Pantelleria. The paleogeographic vicissitudes lead to the inevitable conclusion that the endemic fauna of Lampedusa and Lampione is prevalently relictual, while that of Linosa is invasive. In both cases, they are neo-endemic species of recent formation, evolved from species characterized by a high colonizing capacity and a marked evolutionary speed. This phenomenon is observed, as formerly said, in Tenebrionids, present in the islands with 9 endemic species (see figure 5) on 37 known ones, with a rate of endemism of 24.3% (Lo Cascio, 2002). In particular, the presence in Lampione of 4 endemic taxa, with 2 exclusive subspecies *Opatrum* (*Colpophorus*) *validum rottenbergi* Canzoneri, 1972, *Alphasida puncticollis moltonii* Canzoneri, 1972 - and a species being described (*Tentyria* n. sp., see Lo Cascio & Pasta, 2012), is symptomatic both of the differentiation speed of some species of this family from the founding population and of their capacity to colonise isolated and insular territories (Aliquò, 1995). The insular differentiation is certainly a rather quick phenomenon also among Curculionoidea if, as Osella & Riti (1995) have observed, they are present in Pelagie with 9 endemic species. Of these, 1 species from Lampedusa (*Torneuma clandestinum*) and 1 of Linosa (*Otiorhynchus* (*Arammichnus*) *linussae* A. Solari et F. Solari, 1922) have connections with Tyrrhenian species, while 4 of Lampedusa (*Alaocyba lampedusae* Dodero, 1916; *Neumatora annamariae (*Magrini et al., 2013; *Torneuma extinguendum*; *Otiorhynchus* (*Arammichnus*) *lopadusae* A. Solari et F. Solari, 1922), 1 of Linosa (*Chiloneus* (*Chiloneus*) *solarii* Pesarini, 1970) and 1 of Lampione, *Otiorhynchus* (*Arammichnus*) *poggii* Di Marco, Osella et Zuppa, 2002, show northern African affinities. From relictual populations witnessing the ancient connection between Lampedusa and Northern Africa, too, derive the Orthoptera Brachyptera *Omocestus lopadusae* (La Greca, 1973) and *Pamphagus ortolaniae* Cusimano & Massa, 1977 (Massa, 1995b; Massa, 2011) and the Buprestid Beetle *Julodis onopordi lampedusanus* Tassi, 1966. Particularly interesting under the biogeographical profile is *Leptotyphlopsis lopadusae* Bordoni, 1973, an underground Staphylinidae belonging to a group revolving around the Northern Mediterranean but also present is Tunisia, and well differentiated both from African and Italian congeners. According to Bordoni (1973) it is a species belonging to a very old phyletic lineage, which differentiated after the climate changes of the Quaternary.

For the terrestrial molluscs, it is of particular biogeographical importance the presence of the genus *Lampedusa* Boettger, 1877 including *L. lopadusae* (Calcara, 1846) endemic of Lampedusa island, *L. lopadusae nodulosa* Monterosato, 1892 endemic of Lampione island, *L. imitatrix* Boettger, 1877 e *L. melitensis* (Caruana-Gatto, 1892) endemic of Maltese Island. *Lampedusa* is akin to *Muticaria* Lindhol, 1925 of South-eastern Sicily and Maltese Islands. Both these genera have affinities with species of groups which are originated in the Balkans and in north-eastern Mediterranean, and colonized these more western territories probably during Messinian Age (Giusti et al., 1995).

Here, the only endemic vertebrate is *Podarcis filfolensis laurentiimulleri* (Bedriaga, 1876) which, according to recent molecular and biochemical survey, differentiated from stocks of populations of *Podarcis sicula* which colonised Pelagie Islands and Maltese Islands during pleistocenic regressions (see La Mantia & Lo Cascio, 2008; Sciberras & Schembri, 2008 - see also note 16 of figure 6)

Island of Pantelleria

Pantelleria is a volcanic island, emerged approximately 324,000 years ago, and since then it has never had contacts with emerged land (Agnesi & Federico, 1995). The most relevant event, which determined the actual faunistic composition, was the eruption that about 45 thousand years ago entirely covered the island with a layer of stone 5 metres thick ("green ignimbrite"). It is highly likely that this destroyed the most part of the existent flora and fauna. Most of the endemic species of Pantelleria

(20 taxa pointed out) are then neoendemic species, which differentiated in relatively recent times starting from some founding propagules that re-colonized the island following two main lines: from Sicily and Northern Africa (cf. Francini Corti & Lanza, 1973; Massa, 1995b). Endemic species akin to Northern African species are allegedly the Isopod *Spelaeoniscus vandeli* Caruso, 1974, the Orthoptera *Gryllotalpa cossyrensis* Baccetti et Capra, 1978 (Baccetti et al., 1995a), the Buprestid Beetle *Acmaeodera bipunctata romanoi* Sparacio, 1992 (Sparacio, 1992; Sparacio & Ratti, 1995), the Curculionid Beetle *Alaocyba separanda* Dodero, 1916 (cf. Massa, 1995b) and *Echinodera diottii* (Stuben, 2010), and Melolonthid Coleoptera *Pseudoapterogyna euphytus lamantiai* (Sparacio, 2014). The Curculionid Beetles *Otiorhynchus* (*Arammichnus*) *cossyrensis* Magnano, 1992 e *Pseudomeira cossyrica* (Osella & Riti, 1995) have uniquely Tyrrhenian affinities. The Pselaphid *Tychomorphus cossyrensis* (Dodero, 1919) is part of a genus of strictly West-Mediterranean diffusion (Poggi, 1995), while to a species with Mediterranean Geonemy belongs the only heteropter endemic of Pantelleria, *Apterola* (*Apterola*) *kuenckeli focarilei* Tamanini, 1964. The biogeographical interpretation of the Oedemerid Coleoptera *Stenostoma cossyrense* Bologna, 1995. This species belongs to a genus that includes 3 endemic species found, other than in Pantelleria, in Madera and Maltese Islands, as well as a very diffused Western-Mediterranean-Atlantic species. It is likely, then, that it belongs to a very ancient genus, with paleomediterranean distribution, whose original area fragmented more recently in the present islands where it rapidly evolved for the founder principle (Bologna, 1995; Massa, 1995b). Hardly explainable is also the presence of *Leptanilla poggii* Mei, 1995, a hymenoptera formicidae included in a genus with scarce dispersive capacities. The most likely hypothesis is, according to Mei (1995), the introduction for anthropic cause from Northern Africa in an unspecified moment of the recent history of the island. To anthropic reasons, too, is connected the presence of the Muridae mammal *Apodemus sylvaticus hermani* Felten et Storch, 1970 and of *Crocidura pachyura cossyrensis* Contoli, 1990 (Sarà & Zanca, 2008; Angelici et al., 2009).

Figure 1. Aeolian Archipelago: Panarea Island.

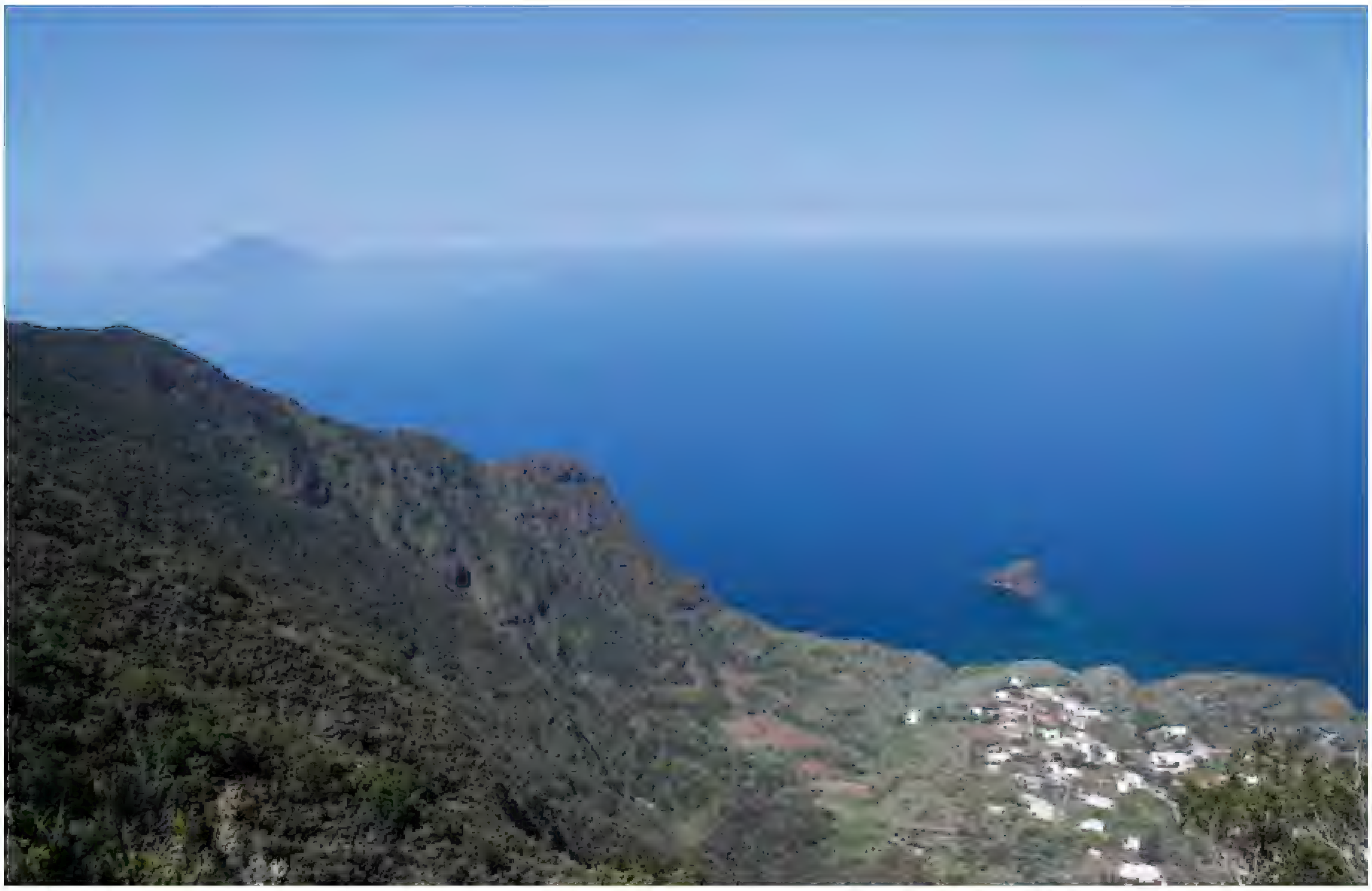


Figure 2. Aeolian Archipelago: Salina Island, Pollara.

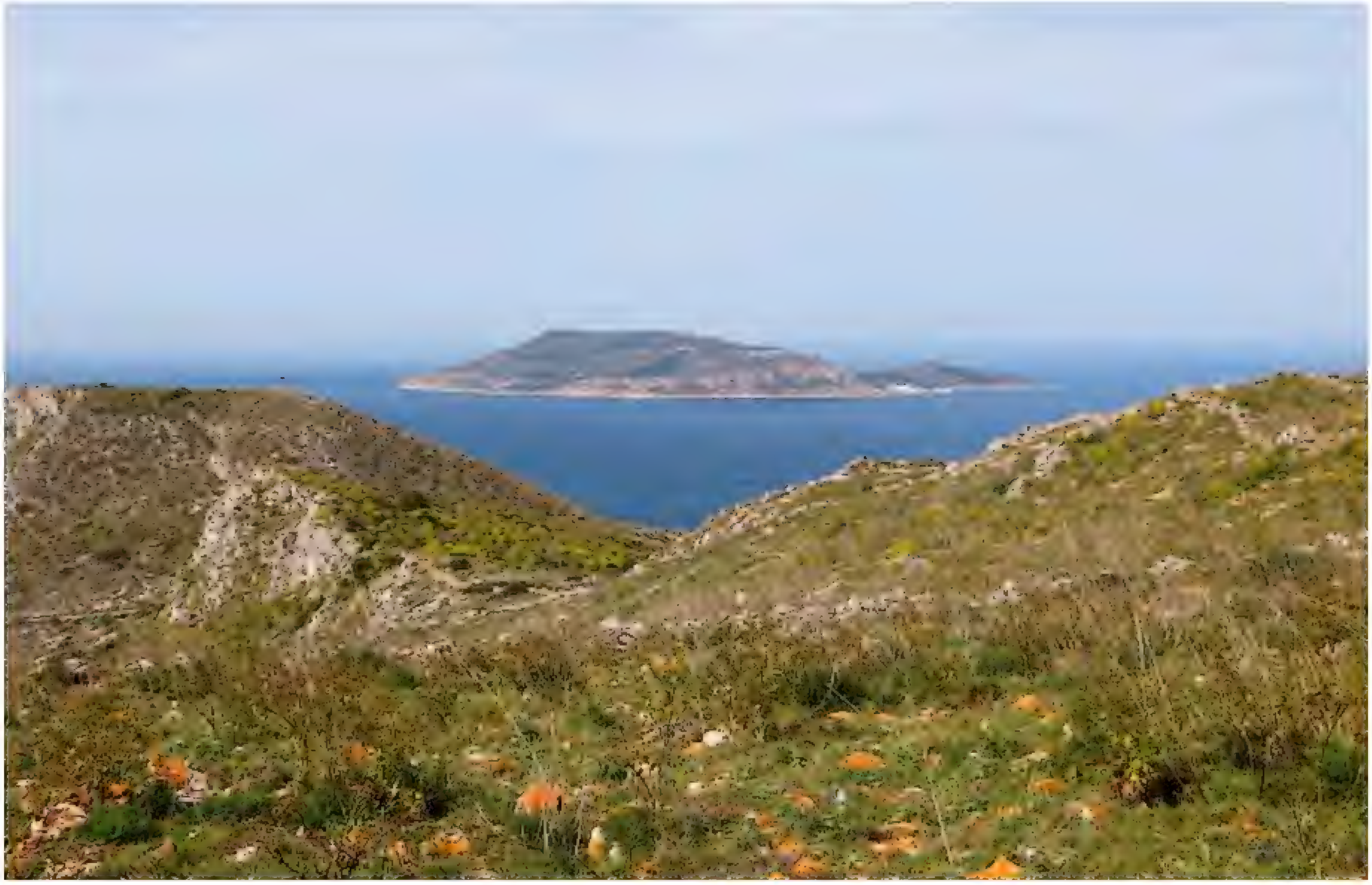


Figure 3. Egadi Archipelago: Favignana Island with Levanzo Island in the background.

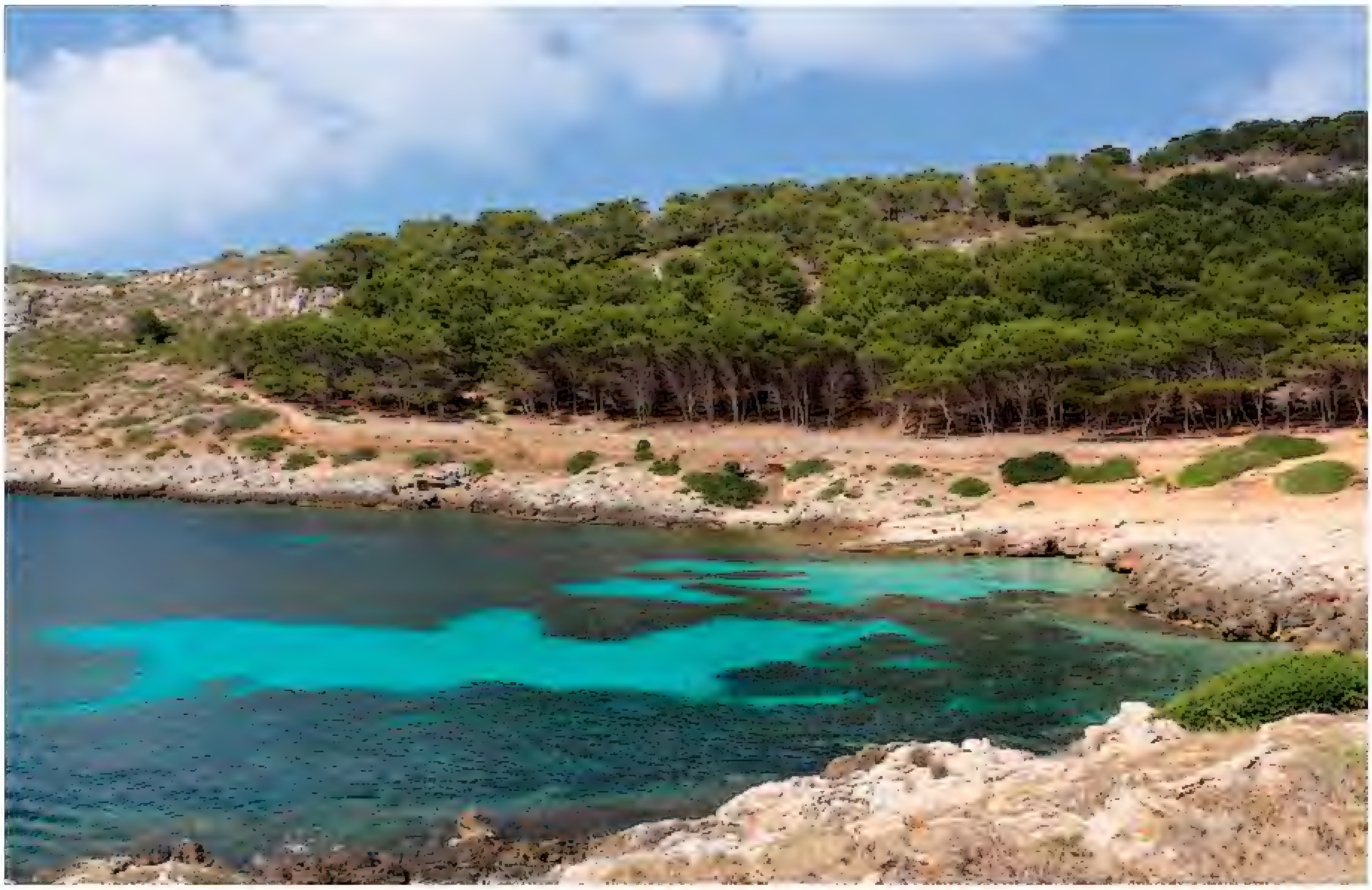


Figure 4. Egadi Archipelago: Levanzo Island, Cala Minnola.

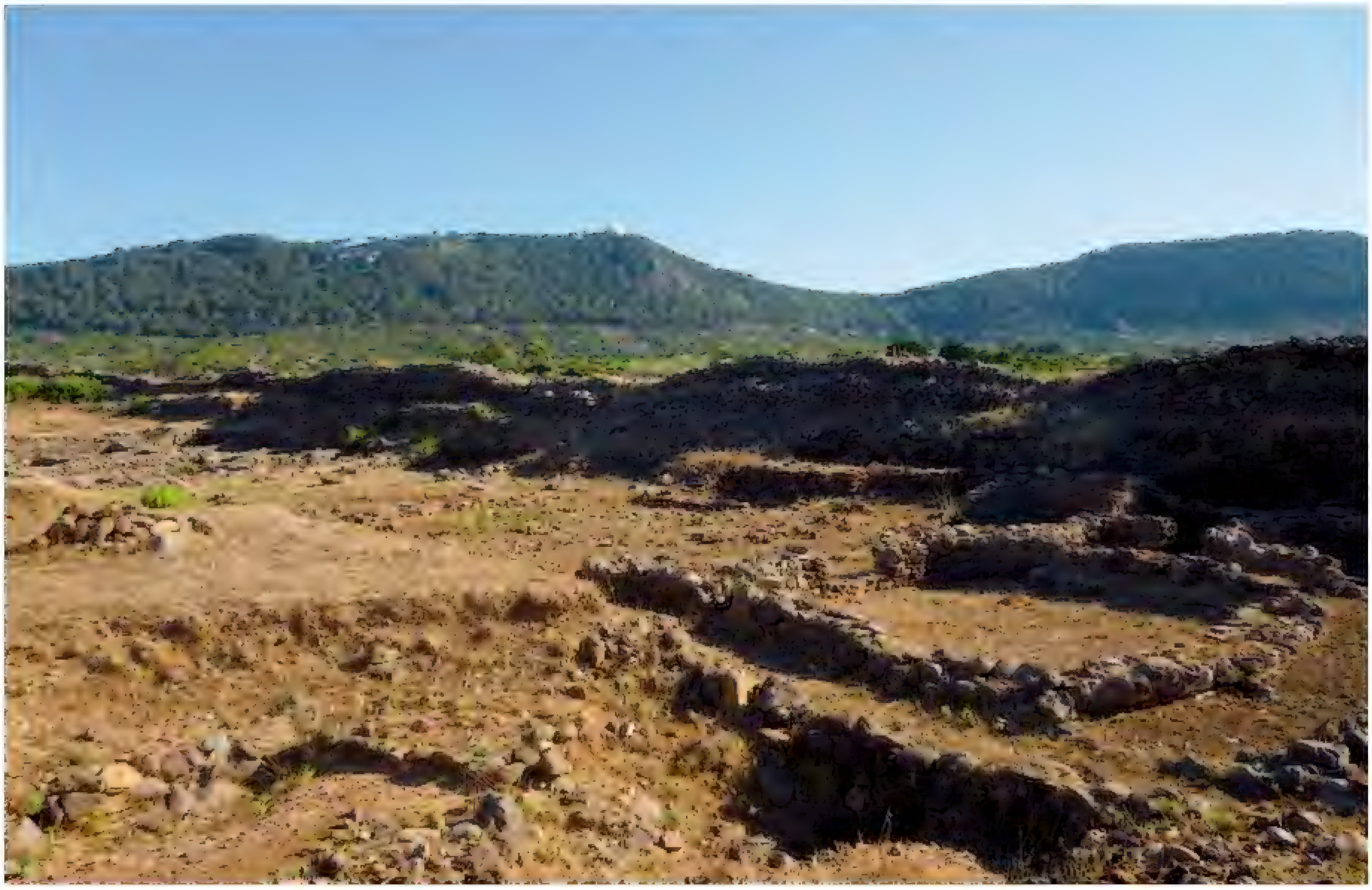


Figure 5. Island of Ustica, Mount Guardia dei Turchi.

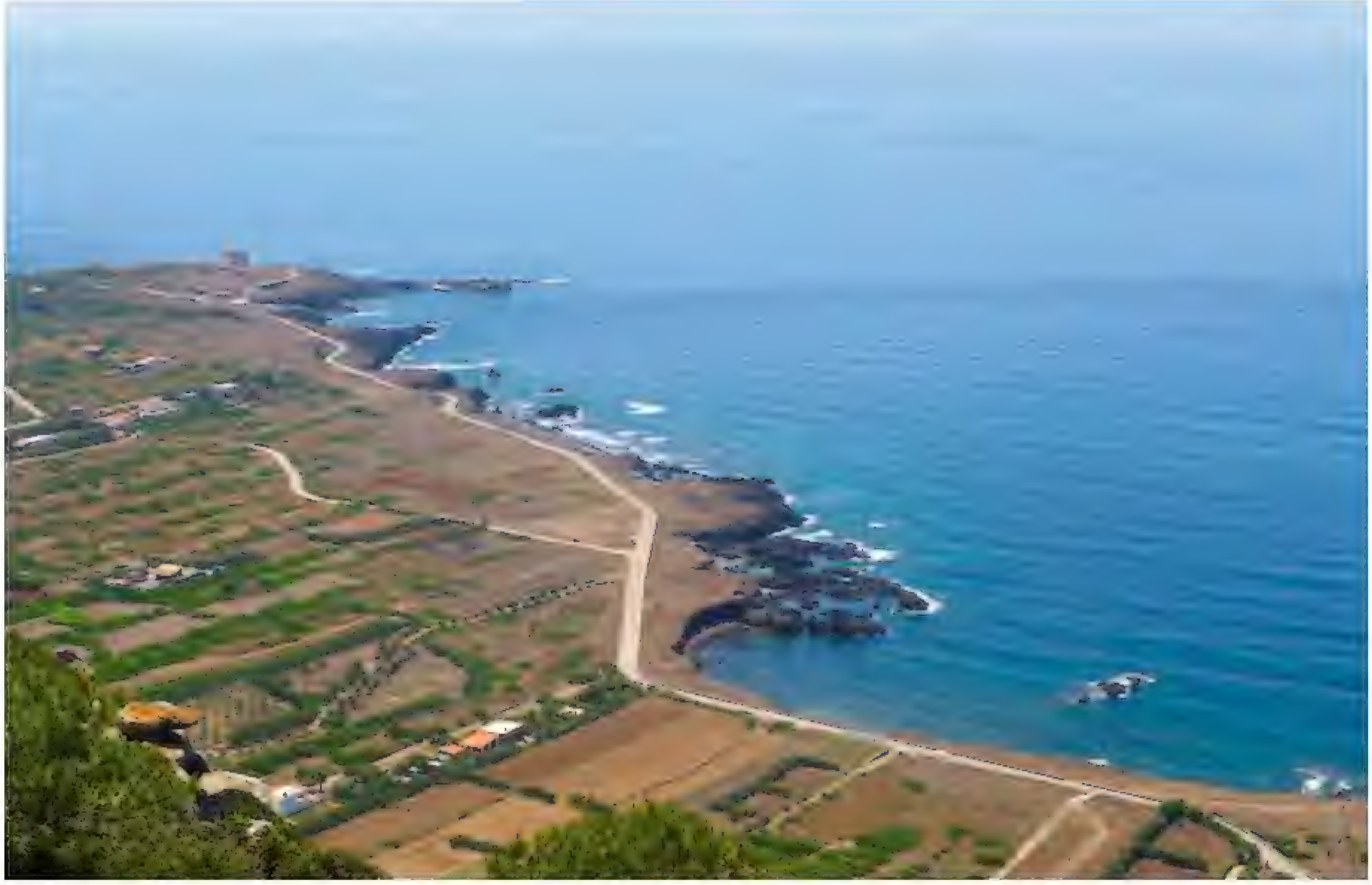


Figure 6. Island of Ustica, Cala Sidoti and Punta Spalmatore.

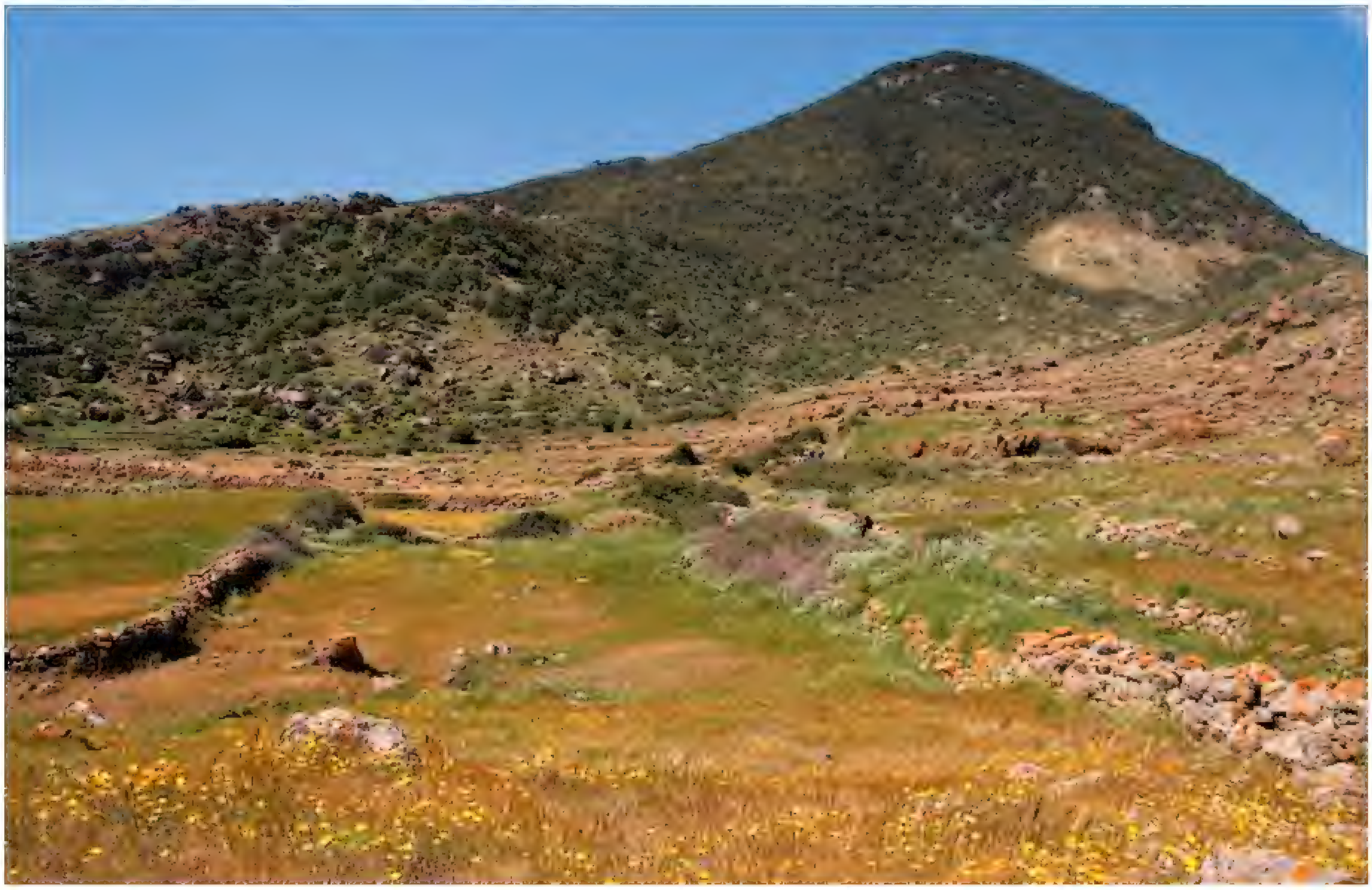


Figure 7. Island of Pantelleria, Montagna Grande.

Figure 8. Island of Pantelleria, Lake of Venus.

Figure 9. Island of Pantelleria.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
ARTHROPODA																
ARACHNIDA ARANEAE DYSDERIDAE																
Dysdera flagellata Grasshoff, 1959												X				Grasshoff, 1959*; Pesarini, 1995; Pantini & Isaia, 2015
Dysdera flagellifera aeoliensis Alicata, 1973					X											Alicata, 1973*; Pantini & Isaia, 2015
Harpactea aeoliensis Alicata, 1973					X											Alicata, 1973*; Pantini & Isaia, 2015
SALTICIDAE																
Aelurillus lopadusae Cantarella, 1983*												X				Cantarella T., 1983*; Azarkina & Loguov, 2006; Pantini & Isaia, 2015
ORIBATIDA PASSALOZETIDAE																
Passalozetes paucesculptus Bernini, 1973											X					Bernini, 1973*
PSEUDOSCORPIONIDA CHTHONIDAE																
Chthonius (*Ephippiochthonius*) *aegatensis* Callaini, 1989*			X													Callaini, 1989*; Stoch, 2006; Gardini, 2013
HEXAPODA BLATTARIA ECTOBIDAE																
Ectobius aeoliensis Failla et Messina, 1974						X		X		X						Failla et al., 1973*; Failla & Messina, 1974; Stoch, 2006
Ectobius filicensis Failla et Messina, 1974								X								Failla & Messina, 1974*; Stoch, 2006
Ectobius parvosacculatus Failla et Messina, 1974											X					Failla et al., 1973*; Failla & Messina, 1974; Stoch, 2006
Ectobius usticaensis Failla et Messina, 1974				X												Failla et al., 1973*; Failla & Messina, 1974; Stoch, 2006
COLEOPTERA BUPRESTIDAE																
Acmaeodera bipunctata romanoi Sparacio, 1992															X	Sparacio & Ratti*, 1995; Stoch, 2006
Anthaxia (*Haplantaxia*) *flaviae* Lo Cascio et Sparacio, 2010					X			X			X					Lo Cascio et al., 2006*; Lo Cascio & Sparacio, 2010
Julodis onopordi lampedusanus Tassi, 1966												X				Tassi, 1966*; Sparacio & Ratti, 1995; Stoch, 2006
CANTHARIDAE																
Malthinus egadiensis Švihla, 2009			X													Švihla, 2009*
CARABIDAE																
Carabus morbillosus lampedusae Born, 1925												X				Rapuzzi & Sparacio, 2015
Ocys beatricis Magrini, Cecchi et Lo Cascio, 2000					X											Magrini et al., 2000*; Lo Cascio & Navarra, 2003
Typhloreicheia berninii Magrini, Bastianini et Petrioli, 2003			X													Magrini et al., 2003*

Table 1/1. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
CHRYSOMELIDAE																
Pachybrachis osellai Daccordi et Ruffo, 1975		X	X													Daccordi & Ruffo, 1975*; Stoch, 2006
COCCINELLIDAE																
Scymnus (*Scymnus*) *caprai* Canepari, 1983															X	Canepari, 1983*, 1995
CURCULIONIDAE																
Alaocyba ientilei Baviera, 2010			X													Baviera, 2010*
Alaocyba lampedusae Dodero, 1916												X				Dodero, 1916*; Osella & Riti, 1995; Stoch, 2006;
Alaocyba separanda Dodero, 1916															X	Dodero 1916*; Osella & Riti, 1995; Stoch, 2006
Chiloneus (*Chiloneus*) *solarii* Pesarini, 1970													X			Pesarini, 1970a, b*; Osella & Riti, 1995
Echinodera diottii Stuben, 2010															X	Stuben, 2010*
Neumatora annamariae Magrini, Abbazzi et Petrioli, 2013												X				Magrini et al., 2013*
Otiorhynchus (*Arammichnus*) *aegatensis* Magnano, 1992	X	X	X													Magnano, 1992*; Baviera & Magnano, 2010; Stoch, 2006
Otiorhynchus (*Arammichnus*) *cossyrensis* Magnano, 1992															X	Solari & Solari, 1922a*; Magnano, 1992; Stoch, 2006
Otiorhynchus (*Arammichnus*) *linussae* Solari et Solari, 1922													X			Solari & Solari, 1922b*; Magnano 1992; Baviera & Magnano, 2010
Otiorhynchus (*Arammichnus*) *lopadusae* Solari et Solari, 1922												X				Solari & Solari, 1922a*; Magnano, 1992; Stoch, 2006
Otiorhynchus (*Arammichnus*) *meligunensis* Magnano, 1992					X	X	X	X	X	X	X					Solari & Solari, 1922a*; Magnano, 1992; Stoch, 2006
Otiorhynchus (*Arammichnus*) *poggii* Di Marco, Osella et Zuppa, 2002														X		Di Marco et al., 2002*; Lo Cascio & Pasta, 2012
Pseudomeira cossyrica Pierotti et Bellò, 1994															X	Pierotti & Bellò, 1994*; Osella & Riti, 1995; Stoch, 2006
Pseudomeira aeolica Bellò, Pesarini et Pierotti, 1997						X	X	X	X	X						Bellò et al., 1997*; Stoch, 2006; Bellò & Baviera, 2011
Torneuma clandestinum Magnano et Mifsud, 2001												X				Osella & Riti, 1995; Magnano & Mifsud, 2001; Stoch, 2006
Torneuma extinguendum Magnano et Mifsud, 2001												X				Osella & Riti, 1995; Magnano & Mifsud, 2001; Stoch, 2006
MELOLONTHIDAE																
Anoxia (*Mesanoxia*) *matutinalis moltonii* Sabatinelli, 1976						X										Sabatinelli, 1976; Lo Cascio & Navarra, 2003
Firminus massai Arnone, Lo Cascio et Grita 2014					X		X	X			X					Arnone et al., 2014*
Pseudoapterogyna euphytus lamantiai Sparacio, 2014															X	Ragusa, 1875*; Sparacio, 2014

Table 1/2. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
MELYRIDAE																
Danacea (*Allodanacaea*) *caneparii* Liberti, 1985															X	Liberti, 1995
Danacea (*Danacea*) *hierena* Baviera et Liberti, 2010	X	X	X													Baviera & Liberti, 2010*
MORDELLIDAE																
Mordellistena (*Mordellistena*) *irritans* Franciscolo, 1991												X				Franciscolo, 1991*; Massa, 1995
SCRAPTIIDAE																
Anaspis (*Larisia*) *akaira* Franciscolo, 1991												X				Franciscolo, 1991*; Lo Cascio et al., 2002; Massa, 1995a, b
SCYDMAENIDAE																
Pseudoeudesis sulcipennis lampedusae Binaghi, 1948												X				Massa, 1995a, b; Sparacio, 1995
STAPHYLINIDAE																
Entomoculia hieratica Poggi et Baviera, 2013			X													Poggi & Baviera, 2013*
Leptotyphlopsis lopadusae Bordoni, 1973												X				Bordoni, 1973*; Massa, 1995a, b; Sparacio, 1995
Tychomorphus cossyrensis (Dodero, 1919)															X	Sparacio, 1995
TENEBRIONIDAE																
Alphasida (*Glabrasida*) *puncticollis moltonii* Canzoneri, 1972														X		Canzoneri, 1972*; Aliquò & Soldati, 2010; Stoch, 2006
Alphasida (*Glabrasida*) *puncticollis tirellii* Leoni, 1929												X				Canzoneri, 1972; Aliquò & Soldati, 2010; Stoch, 2006
Allophylax costatipennis godenigoi Canzoneri, 1970			X													Canzoneri, 1970*; Aliquò & Soldati, 2010
Asida (*Asida*) *minima* Reitter, 1917												X				Aliquò & Aliquò 2000; Stoch, 2006
Erodius (*Erodius*) *audouini destefanii* Failla Tedaldi, 1887												X				Aliquò & Soldati, 2010
Heliopathes avarus donatellae Canzoneri, 1970															X	Ragusa, 1897; Canzoneri, 1968; Aliquò & Soldati, 2010
Machlopsis doderoi Gridelli, 1930												X		X		Gridelli, 1960; Aliquò & Aliquò, 2000; Osella & Riti, 1995
Nalassus pastai Aliquò, Leo et Lo Cascio, 2006						X										Aliquò et al., 2006*
Odocnemis ruffoi ruffoi (Canzoneri, 1970)			X													Canzoneri, 1970*; Aliquò, 2010
Opatrum (*Colpophorus*) *validum marcuzzii* Canzoneri, 1972				X												Riggio, 1885*; Gridelli, 1960, Aliquò & Soldati, 2010
Opatrum (*Colpophorus*) *validum rottenbergi* Canzoneri, 1972														X		Canzoneri, 1972; Goggi, 2004
Pachychila (*Pachychilina*) *dejeani doderoi* Peyerimhoff, 1927													X			Canzoneri, 1972; Aliquò, 2010; Stoch, 2006

Table 1/3. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
TENEBRIONIDAE																
Phaleria (Phaleria) bimaculata marcuzzii Aliquò, 1993					X	X	X	X								Aliquò, 1993; Marcuzzi, 1996; Aliquò, 2010
Probaticus (Pelorinus) cossyrensis Sparacio, 2007															X	Sparacio, 2007
Stenosis brignonei Koch, 1935												X	X			Aliquò & Soldati, 2010; Stoch, 2006;
Tentyria grossa sommieri Baudi, 1874													X	X		Canzoneri, 1972; Aliquò, 2010; Stoch, 2006;
Tentyria grossa angustata (Kraatz, 1896)															X	Canzoneri, 1972; Aliquò, 2010
Trachyscelis aphodioides lopadusae Koch, 1935												X				Failla, 1886*; Luigioni, 1929; Goggi, 2004
COLLEMBOLA ENTOBRYIDAE																
Pseudosinella aeolica Dallai, 1973								X								Dallai, 1973*
Seira dagamae Dallai, 1973					X	X	X									Dallai, 1973*
ISOTOMIDAE																
Folsomides meridionalis Dallai, 1973					X	X	X	X	X	X	X					Dallai, 1973*
NEANURIDAE																
Friesea lagrecai Dallai, 1973						X	X	X	X	X	X					Dallai, 1973*
ONYCHIURIDAE																
Onychiurus lampedusae Dallai, 1978												X				Dallai, 1973*
HETEROPTERA LYGEIDAE																
Apterola (Apterola) kuenckeli focarilei Tamanini, 1964															X	Tamanini, 1964*; Carapezza, 1995
Plinthisus (Isioscytus) minutissimus meridionalis Mancini, 1935*															X	Carapezza, 1995
MIRIDAE																
Tuponia (Chlorotuponia) hippophaes liparensis Tamanini, 1973*						X		X								Tamanini, 1973*; Ippolito, 1986
Phytocoris (Ktenocoris) cossyrensis Carapezza, 1995			X												X	Carapezza, 1995*
HOMOPTERA CICADELLIDAE																
Adarrus aeolianus D'Urso, 1984					X			X								D'Urso, 1984*; Stoch, 2006
ISSIDAE																
Conosimus malfanus Dlabola, 1987			X					X								Lo Cascio & Pasta, 2004
HYMENOPTERA FORMICIDAE																
Leptanilla poggii Mei, 1995															X	Mei, 1995*
Tetramorium pelagium Poldi in Mei, 1995													X			Mei, 1995*

Table 1/4. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
MUTILLIDAE																
Physetopoda silviae Pagliano, 2011												X				Pagliano, 2003*, 2011
LEPIDOPTERA SATYRIDAE																
Hipparchia leighebi Kudrna, 1976					X	X	X	X			X					Kudrna, 1976*; Kudrna & Leigheb, 1988; Stoch, 2006
ORTHOPTERA ACRIDIDAE																
Omocestus lopadusae (La Greca, 1973)												X				Baccetti et al., 1995a, b; Stoch, 2006; Massa, 2011
GRYLLOTALPIDAE																
Gryllotalpa cossyrensis Baccetti et Capra, 1978															X	Baccetti & Capra, 1978; Baccetti et al., 1995a, b; Stoch, 2006; Massa, 2011
PAMPHAGIDAE																
Acinipe galvagnii Cusimano et Massa, 1977	X	X	X													Cusimano & Massa, 1977*; Stoch, 2006; Massa, 2011
Pamphagus ortolaniae Cusimano et Massa, 1977												X				Cusimano & Massa, 1977; Stoch, 2006; Massa, 2011
PHASMIDA BACILLIDAE																
Bacillus grandii maretimi Scali et Mantovani, 1990			X													Berni, 1996
MALACOSTRACA ISOPODA ARMADILLIDAE																
Armadillidium hirtum pelagicum Arcangeli, 1955														X		Caruso & Lombardo, 1995
BATHYTROPIDAE																
Bathytropa ruffoi Caruso, 1973			X													Schmalfuss, 2003
SPELAEONISCIDAE																
Spelaeoniscus costai Caruso et Lombardo, 1976				X												Caruso & Lombardo, 1995
Spelaeoniscus lagrecai Caruso, 1973			X													Caruso & Lombardo, 1995
Spelaeoniscus vandeli Caruso, 1974															X	Caruso & Lombardo, 1995
CHORDATA																
MAMMALIA INSECTIVORA SORICIDAE																
Crocidura sicula aegatensis Hutterer, 1991*	X	X	X													Hutterer, 1991; Angelici et al., 2009; Sarà, 1995; Stoch, 2006
Crocidura pachyura cossyrensis Contoli, 1990															X	Angelici et al., 2009; Stoch, 2006
RODENTIA GLIRIDAE																
Eliomys quercinus liparensis Kahamann, 1960					X											Angelici et al., 2009; Stoch, 2006
MURIDAE																
Apodemus sylvaticus hermani Felten et Storch, 1970															X	Angelici et al., 2009; Stoch, 2006

Table 1/5. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
REPTILIA SQUAMATA LACERTIDAE																
Podarcis filfolensis laurentmulleri Fejervari, 1924												X	X	X		Capula,1994; Sindaco et al., 2006; Stoch, 2006
Podarcis raffoneae alvearioi (Mertens, 1955)						X		X		X						Capula, 2006; Sindaco et al., 2006; Stoch, 2006
Podarcis raffoneae antoninoi (Mertens, 1952)*						X										Capula, 2006; Sindaco et al., 2006; Stoch, 2006
Podarcis raffoneae raffoneae (Mertens, 1952)							X									Capula, 2006; Sindaco et al., 2006; Stoch, 2006
Podarcis raffoneae cucchiarai Di Palma, 1980*										X						Capula, 2006; Sindaco et al., 2006; Stoch, 2006
Podarcis sicula liscabiancae (Mertens, 1952)*											X					Corti & Lo Cascio, 1999; Sindaco et al., 2006; Stoch, 2006
Podarcis sicula trischittai (Mertens, 1952)*											X					Corti & Lo Cascio, 1999; Sindaco et al., 2006; Stoch, 2006
Podarcis waglerianus marettimensis (Klemmer, 1956)*			X													Lo Cascio & Pasta, 2008; Sindaco et al., 2006; Stoch, 2006
SQUAMATA SCINCIDAE																
Chalcides ocellatus linosae Boulenger, 1920*													X			Corti & Lo Cascio, 2002; Sindaco et al., 2006; Stoch, 2006
Chalcides ocellatus zavattarii Lanza, 1954*												X				Corti & Lo Cascio, 2002; Sindaco et al., 2006; Stoch, 2006
MOLLUSCA GASTROPODA ARCHITAENIOGLOSSA COCHLOSTOMATIDAE																
Cochlostoma paladilhianum pirajnaea (Benoit, 1878)	X															Manganelli et al., 1995; Bank, 2011
STYLOMMATOPHORA CLAUSIILIDAE																
Lampedusa lopadusae lopadusae (Calcara, 1846)												X				Calcara, 1846*; Liberto et al., 2010
Lampedusa lopadusae nodulosa Monterosato, 1892														X		Liberto et al., 2010; Lo Cascio & Pasta, 2012
Siciliaria (*Siciliaria*) *scarificata* (Pfeiffer, 1857)			X													Liberto et al., 2015
CHONDRINIDAE																
Rupestrella rupestris coloba (Pilsbry, 1918)		X														Beckmann, 2002
COCHLICOPIDAE																
Hypnophila emiliana (Bourguignat, 1858)	X		X													Liberto et al., 2010
Hypnophila incerta (Bourguignat, 1858)					X		X	X		X	X					Giusti, 1973; Liberto et al., 2010
HELICIDAE																
Marmorana (*Murella*) *muralis frivaldszkyi* (Calcara, 1846)															X	Calcara, 1846
Marmorana (*Murella*) *muralis insularis* (Benoit, 1857)			X													Fiorentino et al., 2008a, b

Table 1/6. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

TAXON	FA	LE	MA	US	LI	VU	ST	SA	AL	FI	PA	LM	LN	LA	PN	REFERENCES
HYGROMIIDAE																
Cernuella metabola (Westerlund, 1889)												X				Bank, 2011; Manganelli et al., 1995
Helicotricha carusoi Giusti, Manganelli et Crisci, 1992					X	X	X	X	X	X	X					Giusti et al., 1992
Schileykiella bodoni Cianfanelli, Manganelli et Giusti, 2004			X													Cianfanelli et al, 2004
Trochoidea cumiae (Calcara, 1847)												X		X		Cianfanelli, 2002
LIMACIDAE																
Limax aeolianus Giusti, 1973								X		X						Giusti, 1973; Lo Cascio & Navarra, 2003
ZONITIDAE																
Oxychilus (*Hyalocornea*) *alicurensis* (Benoit, 1857)									X							Benoit, 1857-1862*; Giusti, 1973
Oxychilus (*Hyalocornea*) *egadiensis* Riedel, 1973	X	X														Manganelli et al., 1995
Oxychilus (*Hyalocornea*) *nortoni* (Calcara, 1843)				X												Calcara, 1843; Liberto et al., 2010
Oxychilus (*Hyalofusca*) *denatale* (Pfeiffer, 1856)			X													Manganelli et al., 2007
Oxychilus (*Oxychilus*) *diductus* (Westerlund, 1886)												X				Giusti, 1973; Corti et al., 2002
Oxychilus (*Oxychilus*) *lagrecai* Giusti, 1973										X						Giusti, 1973*

Table 1/7. Endemic taxa of circum-sicilian island listed by alphabetic order and relative distribution. For the abbreviation of the islands see Table 2. The species followed by * have not been taken into consideration for the elaboration of the Tables.

CONCLUSIONS

The study of the populations of the circum-sicilian islands, as we have seen, is particularly complex (see also Francini Corti & Lanza, 1973 and Massa et al., 2011), as these islands vary substantially for their origin (volcanic or sedimentary), paleogeography (some have been connected to Sicily or the African continent during pleistocenic regressions, other have remained isolated), distance from the main source of colonisation (Sicily or Africa), surface (Malta, the biggest island, has a surface of 245.7 km^2 but most of the islands are smaller than 30 km^2) and environmental conditions. Besides, their position at the border between Europe and Africa makes their faunistic composition a mosaic of European and African elements (Francini Corti & Lanza, 1973; Massa 1995b, 2011) with important implications of preservation (Fattorini, 2008, 2011).

The conclusions that we draw by analysing as a whole the endemic contingents of circum-sicilian islands and the main factors that have determined the insular differentiation are similar to those proposed by Fattorini (2011) who took into consideration only Tenebrionids:

- in the case of the Aeolian Islands, the new endemic species might have originated by propagules arrived from Sicily especially during the periods of marine regression, when the distance between these islands and Sicily reduced but not annulled; these propagules might have rapidly differentiated due to a marked "bottleneck", accentuated by the volcanic instability of the area. The origin of paleoendemic species is more complex: their genesis is allegedly to be found in the complex geological history or "paleo-Aeolian islands"

- for the Egads we can suppose a substantial colonisation via land for Levanzo and Favignana, while the populations of Marettimo have a prevalently relictual connotation.

- Ustica, Linosa and Pantelleria, of volcanic origin, are very distant from continental areas, with which they would never have gotten into contact, which can explain the fact that they show, almost exclusively, endemic species of new formation.

-Lampedusa and Lampione are very isolated and of ancient origin; we can therefore presume that their endemic contingent derives substantially from a relictual population, above all for the endemic genera (as in Lampedusa), and the oldest species to which other ones (arrived during quaternary contacts with Northern Africa and differentiated during more recent times) have added.

Lastly, we need to consider that all of the circum-sicilian islands have, more or less intensely, undergone profound changes in their natural asset due to anthropic impact, particularly with the destruction of most of their original woods. This, presumably, has led to the extinction of some taxa and to the high rarefaction of others.

The ecological and biogeographical importance of point endemic species is proportional to their fragility, therefore we believe that it is particularly important and urgent to adopt specific protection measures such as the already mentioned Direttiva 92/43 CEE ("Direttiva habitat"): "*they are endemic and need particular attention, considered the specificity of their habitat and/or the potential incidence of its exploitment on their state of conservation*".

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MONOGRAPH

Qanat, gebbie and water sources: the last refuge for the malacological freshwater fauna in Palermo (Sicily, Italy)

Ignazio Sparacio[1], Tommaso La Mantia[2*], Maria Stella Colomba[3], Fabio Liberto[4], Agatino Reitano[5] & Salvo Giglio[6]

[1]Via Principe di Paternò 3, 90144 Palermo, Italy; e-mail: edizionidanaus@gmail.com
[2]Università degli Studi di Palermo Dip. SAAF, Viale delle Scienze ed. 4 , 90128 Palermo, Italy; email: tommaso.lamantia@unipa.it
[3]Università di Urbino, Dept. of Biomolecular Sciences, via Maggetti 22, 61029 Urbino, Italy; email: mariastella.colomba@uniurb.it
[4]Via del Giubileo Magno 93, 90015 Cefalù, Italy; email: fabioliberto@yahoo.it
[5]Museo Civico di Storia Naturale di Comiso, via degli Studi 9, 97013 Comiso, Italy; e-mail: tinohawk@yahoo.it
[6]Contrada Settefrati, 90015 Cefalù, Italy; email: hallucigenia@tiscali.it
*Corresponding author

ABSTRACT The surroundings of Palermo were characterized, over the centuries, by the presence of many natural environments of great ecological and faunal importance. These environments were placed in a context characterized by minimal and sustainable urban development and large agriculture areas, dedicated to the development of tree crops such as citrus and orchards. These crops were supported by an imposing irrigation system that, using natural resources such as watercourses, wells and springs, collected and distributed water in soils through tanks, gebbie, qanat, irrigation channels (saje), etc. Fresh water mollusks, like many other animal and vegetable organisms, spread from the natural freshwater environments in this artificial water system, thus creating a unique and varied ecosystem. The subsequent urban development of the city of Palermo and the destruction of many of those natural environments has further enhanced the ecological role of the artificial freshwater systems as an important refuge for the native fauna and flora. In the present study, we report on freshwater molluscs observed in the territory of Micciulla, a large relict area occupied almost entirely by an old citrus, now located inside the city of Palermo. In this area there are some springs, an extensive array of artificial freshwater to irrigate the crops, and the qanat Savagnone located in the "Camera dello Scirocco". The results obtained by census of different populations of freshwater mollusks confirm the importance of these environments and the growing role they play as the last refuges for fauna and flora originally linked to natural humid environments.

KEY WORDS Palermo Plain; agroecology; orchards; ecology; freshwater mollusks.

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INTRODUCTION

The Palermo Plain is about 130 sqkm wide, with NW-SE direction and an average slope of 10–15%. It is bordered to the West by the mountains of Palermo, to SE by the Eleuterio river, to NE by the Tyrrhenian Sea. The mountains of Palermo reach an average height of 900 m a.s.l., with very steep slopes and consist of limestones and dolomites with high degree of fracturing and permeability. The main peaks are Mount Gallo, Mount Pellegrino, Belmonte-Pizzo Mirabella, Mount

Grifone, Orecchiuta, Pizzo Valle Fico, Costa Lunga, Gibilmesi, Busilmeri, Mount Caputo, Mount Cuccio, Cozzo Di Lupo, Mount Gibilforni, Mount Castellaccio.

The Palermo Plain consists of Pleistocene deposits (Calcarenites and sandy clays of Ficarazzi) that lie on waterproof soils of clay and marne of the Numidic Flysch (Oligo-Miocene), beneath these latters there are meso-cenozoic limestones (Abate et al., 1978; Catalano et al., 1979).

Two aquifers are recognized, the superficial one into Pleistocene sandy-clay and calcarenites, and the deep one (below 100 m deep) into Mesozoic limestones. The two aquifers are discontinuously separated by the waterproof Flysch (Calvi et al., 1998).

The waters that leak in carbonate rocks of Palermo Mountains supply the deep aquifer and in part the superficial one. Where they encounter waterproof soils emerge suppling superficial springs. The waters of Mount Cuccio and Mount Gibilmesi, for example, emerge in the Gabriele spring group and are employed, ever since, for irrigation or drinking-water use.

The waterways and main canals were (and still partly are) part of the Oreto River, including the Papireto River, the Kemonia Stream and the Passo di Rigano Canal (cfr. Cusimano et al., 1989). The Oreto River originates from Portella di Renda, south of Palermo, at 786 m a.s.l. and flows toward the sea, always on the eastern side of the Palermo Plain. It was and is, despite centuries of deep alterations by Man, an important natural environment. At its mouths there were coastal wetlands called the Pantani dell'Oreto or Pantani di Cascino, finally dried up around 1750. The Papireto (or Conceria) River flowed northwest of the ancient Palermo town and originated from the Danisinni Depression; it was about 3 km long and was transformed into an underground sewer in 1591.The Kemonia torrent (also known as “river of bad weather”) flowed southwest of the old city of Palermo, forming the mid-terminal stretch of Sambucia-Cannizzaro, below Monreale and, after receiving several tributaries, continued its path through the Fossa della Garofala, Ballarò and Albergheria; it was transformed into a sewerage system around 1700. In 1560 part of its waters (i.e. Cannizzaro’s ones) were diverted to the Oreto River through the so-called Badami canal. The Passo di Rigano canal, built in 1856, collects the streams of water upstream of the city, but also streams such as the Bellolampo watercourse which until the 1800s crossed the city up to the S. Lucia pier.

Numerous wetlands surrounded the Palermo Plain thanks to some favorable ecological and topographic conditions. At the base of Mount Grifone, locality San Ciro, there was a large water reservoir, so-called “Favara”, Arabic name bearing witness of abundant waters. This “Favara” received the water from a spring at the base of the mountain and it is so large to be deserved the name “Maredolce” (= Fresh Sea). On the shores of this lake was the Castle of Jafar, the summer residence of the regal emirs during the Arab domination (see Barbera et al., 2015; Pasta, 2015). Another import-ant coastal wetland was the “Pantano of Mondello”, inserted into a natural coastal dune system, which throughout the 1800s was gradually dried up to the definitive disappearance around 1890. Even the surrounding dune system was, in the same period, profoundly altered and completely destroyed in the early 1900s.

There are numerous reports on the presence in these places of plant and animal species of particular naturalistic value (see Calcara, 1841; 1845; Doderlein, 1869; Ragusa, 1874, 1883, 1892–1893, 1896–1897, 1919; De Stefani Perez & Riggio, 1882; Lapiana & Sparacio, 2008).

This freshwater abundance, but also the need to census them for use, determined a huge and detailed amount of information on the item since the Arab period (Gaetani, 1777–1789; cfr. La Duca, 1986; Lo Piccolo, 1994).

The history of Palermo is intimately linked to the spread of irrigation techniques (Bresc, 1972) which, initially introduced by the Arabs, have for centuries had a development that has conditioned the choice of crops and ultimately the landscape of the Palermo Plain, and, especially, that part of citrus groves closest to Palermo, called Conca d’Oro (La Mantia, 2006, 2007).

The superficial acquifer of the Palermo Plain has was so pick up with vertical shafts and horizontal tunnels, called “qanat”, where the water flows through gravity on a slight slope; this system has a persian origin (Laureano, 1995; Biancone & Tusa, 1997; Todaro, 2002). The water was estracted by means of water wheels (“senie” or “norie”) driven by mules or horses (See Pizzuto Antinoro, 2003), then replaced in the second half of the nineteenth century by steam engines. The freshwater was accumulated in artificial basins ("gebbie"), finally distributed by means of irrigation canals ("saje") or with castles-water it was divided and distributed in pottery pipes ("catusi") to private house. Almost all of these terms used in water processing are of Arab origin.

This system works for simple gravity providing water without pauperizing the acquifer, without causing evaporation losses and with low pollution risks. During the 1800s, the city had at least 70 castles-water and the water flowed into three canals of sources: Gesuitico, Campofranco and Gabriele.

The oldest qanats were built during the Arab domination of Sicily, but they had the greatest development between the 16th and the 19th centuries. Their length ranges from a few hundred meters to about two kilometers. Once the aquifer was identified, the tunnel was dug starting from its outlet in the direction of the aquifer. The gallery could reach 20 meters deep; connecting wells with the outer surface were made to allow the extraction of the debris and the air entry. When the acquifer was reached, lateral drainage tunnels were dug.

The system, synthetically described, included the presence of other artefacts related to water, mills, watering canines. It began in Roman times and developed especially during the Arab domination. This system has also ecologically shaped the environment as masterly explained by the ecologist Riggio (1976) and many of these structures have carried water for many thousand years. Throughout this long period, the natural-freshwater/artificial-freshwater system represented, therefore, a unique and well structured ecosystem where most living organisms developed in the direct presence of water, or in any wetlands of the whole Palermo plain.

Moreover, especially in the last two centuries, the progressive alteration and destruction of almost all the main natural wetlands of this territory and progressive abandonment and reduction of agrarian environments has make this system the last refuge for the existence and preservation of the igrophilous and freshwater fauna.

For example, the presence of small arthropods is documented in the groundwater and in the network of qanat (Lofrano et al., 2013).

The freshwater molluscs living in the Palermo Plain are among the animal groups those that have most benefited from this context. Throughout the 1800s numerous malachologists and naturalists documented the wealth and peculiarities of these populations around Palermo that lived and developed in a harmonious system of natural and artificial freshwater (Power, 1842 but see also Sparacio, 2012, 2015; Calcara, 1841, 1845; Benoit, 1875, 1882; De Gregorio, 1895). From 1900 onwards, in conjunction with the almost complete destruction of many natural environments, the bibliographic sources on the freshwater molluscs living in the Palermo Plain drastically reduced; nevertheless we can obtain useful indications, at least until 1950, from the works of Cassarà (1948, 1951, 1958). In recent times updated knowledge is contained in the works of Riggio (1976), in the check map of the species of Italian fauna (Bodon et al., 2005), in Lo Brano & Sparacio (2006), Lapiana & Sparacio (2010) and Liberto et al. (2010).

MATERIAL AND METHODS

Study area

The study area is located in the western outskirts of Palermo, enclosed in the city streets Corso Calatafimi, Viale Regione Siciliana, Via G. Pitrè, and Via Altarello di Baida. At the base of Monte Caputo there is the complex of Gabriele's springs, whose waters once reached the Favorita Park (La Mantia, 2004). The complex of Gabriele's springs consists of many sources (see Lo Piccolo, 1993, 1994), some of which were sampled during this survey. The spring water is now partly employed for civil uses; on the other hand, irrigation is made up by using also the waters from the basin of Piana degli Albanesi (15 km south of Palermo), which through surface pipes (saje) or underground canals (catusi) flow to the study area.

Fondo Micciulla is an agricoltural territory which develops around the homonymous Baglio and, at present, is still entirely surrounded by walls. In Sicily the "baglio" is a fortified farm with a large courtyard. Historical information dates back to the end of the 1900s and the use of water for irrigation is a constant in the history of this ground. Next to it is the Santacolomba estate with, in the center, the Villa Belvedere, since 1300. Within the original walls of the Santacolomba estate lies the socalled "room of the sirocco" belonging to Villa Savagnone. This area and in particular Fondo Micciulla is one of the few still cultivated in the western portion of the Conca D'Oro and where water plays an important role in the conservation of the agroecosystem; there are citrus trees (*Citrus* spp.), mixed with loquat trees, *Eriobotrya japonica* (Thunb.) Lindl., but also there are numerous walnut trees, *Juglans regia* L., honeyberry trees, *Celtis australis* L., and other fruit trees (La Mantia, 2007, 2016). At the same time, unfortunately, in other areas of the Palermo Plain can be observed obvious phenomena of abandonment with serious repercussions on the agroecosystem not least of which the spread of invasive alien species (La Mantia, 2006; Badalamenti & La Mantia, 2013).

Gabriele's springs. Altarello di Baida District. Oreto hydrographic basin.

Resource Code: 19PA00 G2001 S0004

Aqueduct Complex "Agro Palermitano", Intercomunal Aqueducts

Average capacity l/s: 180

Annual volume used for civil use [m^3]: 5.676.480 n.d.

Water features: temperature 16.5 °C, calcareous, average capacity estimated at 180 liters per second.

Gabriele's springs, located at the base of Monte Caputo, originate from the cracked mesozoic limestone; they are the sources for which there are the oldest references and a rich iconography available (see Lo Piccolo, 1993). The sources despite the presence of ancient channels aimed at their exploitation since a very long time, have maintained a high level of naturalness with luxuriant vegetation (see Carapelle, 1914; Lo Piccolo, 1993). In particular, Carapelle (1923) writes about the sources that were "*covered with lush vegetation*".

Gabriele's springs have been closed and covered by some concrete structures today, losing their naturalness. The fauna and flora that lived here are found in the nearby **Source of Fontane**, destined for irrigation of the Fontane Consortium (Lo Piccolo, 1994), and in other small and similar neighboring springs. The Source of Fontane shows the most natural features as fully covered by vegetation, particularly *Arundo donax L.*, that reduces the brightness, which in some periods is lightly photic. The substrate of the bottom is sandy, fine, with many decomposing plant debris. Other vegetation that grows at the edges of the spring includes: *Equisetum ramosissimum* Desf., *Adiantum capillus-veneris* L., *Rubus ulmifolius* Schott.

Qanat Gesuitico Alto. The Qanat under investigation, located at Fondo Micciulla, was built at the beginning of the 16th century (Lo Piccolo, 1994). Sampling took place in a Qanat airship shaft, a few hundred meters from where water flows in the direction of the city center.

This qanat is aphotic.

Water features: temperature 12 °C, calcarenite, average capacity estimated at 40 liters per second.

Qanat Scibene. The source of Uscibene or Scibene is born from an underground cave in the Altarello Baida district and feeds a system of qanat; this source has been used for the water supply and irrigation of the fields of Palermo since the 15th century (Todaro et al., 2006). It is so called because it is thought to be used to bring water to the renowned Scibene building, dating back to the Norman period, located a few hundred meters from Villa Savagnone (Lo Piccolo, 1993; Biancone & Tusa, 1997; Todaro, 2002).

In its middle course, the qanat crosses the Villa Savagnone's "Camera dello Scirocco" (Room of Sirocco), another sampling site. The name "Camera dello Scirocco" is used to indicate the environments that guaranteed, thanks to its freshness, shelter in the warm days of the sirocco. Although of earlier origin, spread mainly in the seventeenth century particularly in the villas that, at that time, developed on the plain of Palermo (Todaro, 2002). These were "*underground environments capable of producing fresh ... through the presence of three fundamental elements: an artificial cave, a spring or stream of water and a ventilation well*" (Todaro, 2002). The peculiarity of the room of sirocco at Villa Savagnone is that it was obtained within a quarry of limestone and then cooled by a licking "Qanat" (Todaro, 2002). The vegetation includes *Adiantum capillus-veneris* L., *Hedera helix* L., *Reichardia picroides* (L.) Roth, and *Acanthus mol-*

lis L. that grow above the walls; there are also *Parietaria judaica* L., *Rubus ulmifolius* Schott and *Ulmus minor* Mill., and, in the water, there is the green alga *Pithophora* sp.

The **Villa Savagnone's Qanat** is fed also by the source of Scibene, which originates just upstream of the Camera dello Scirocco.

The Scibene and Villa Savagnone Qanat are lightly photic in the beginning to become aphotics.

Water features: temperature 12 °C, calcarenite, average capacity estimated at 4 liters per second.

Gebbie. Several gebbie were sampled: Gebbia Fratelli La Mantia into Fondo Micciulla, and other three in Fondo Santacolomba; the first is the smollest under the walls of Villa Belvedere, the second at the boundary wall of the Fondo Santacolomba, the third called "Ru gebbi" (two gebbie) as formed by two intercommunicating tanks.

Almost always the gebbie are placed in full light, covered only in part by the surrounding fruit trees. They are surrounded by a rich vegetation that the presence of water contributes to increasing: *Arundo donax* L., *Adiantum capillus-veneris* L., *Plantago major* L., *Marchantia* sp., *Hedera helix* L., *Parietaria judaica* L., *Tradescantia fluminensis* L., *Rubus ulmifolius* Schott. The waters, rich in filamentous algae and *Pithophora* sp., are subject to severe overheating during the summertime days.

Saja.The Saja sampled is located in Fondo Micciulla and it is the main saja from where the water from Gabriele's springs flows to Micciulla. The water is distributed also in the lands contiguous to the Sicilian region road (Chiusa Uscibene) and this determined the almost continuous presence of the water in the summer and partly even in the winter period.

The sources, compared to the gebbies from which saje originate, exhibit greater diversification both in brightness and in water temperature. In fact, in relation to their path, they can slide almost into the darkness between the vegetation or in full light. The waters are cooler and running, but there are also long periods of stagnation with drying.

The vegetation is the same of the gebbie but the saje can also cross natural areas where there are other tree and herbaceous species such as *Ulmus minor* Mill., *Fraxinus*, *Smilax aspera* L., *Rubia peregrina* L., etc.

Water tanks. Various small tanks are present throughout the territory of Micciulla, used for ornamental purposes, one of which had a populations of freshwater mollusks (Table 1).

Sampling methods

The samples have been collected by I. Sparacio and T. La Mantia from 2009 to 2016 during several excursions carried out in the study area every three months (see Figs. 1, 2; Table 1). Live specimens for taxonomic studies were collected only in 29.X.2009, 9.XII.2009, 18.IV.2012 and 20.VIII.2014. The other samplings were of empty shells and with the direct observation for census of living populations in order not to harm these environments. All the lots are kept in the authors collections and, some samples, in M. Bodon collection (Genova, Italy) and R. Viviano collection (Palermo, Italy).

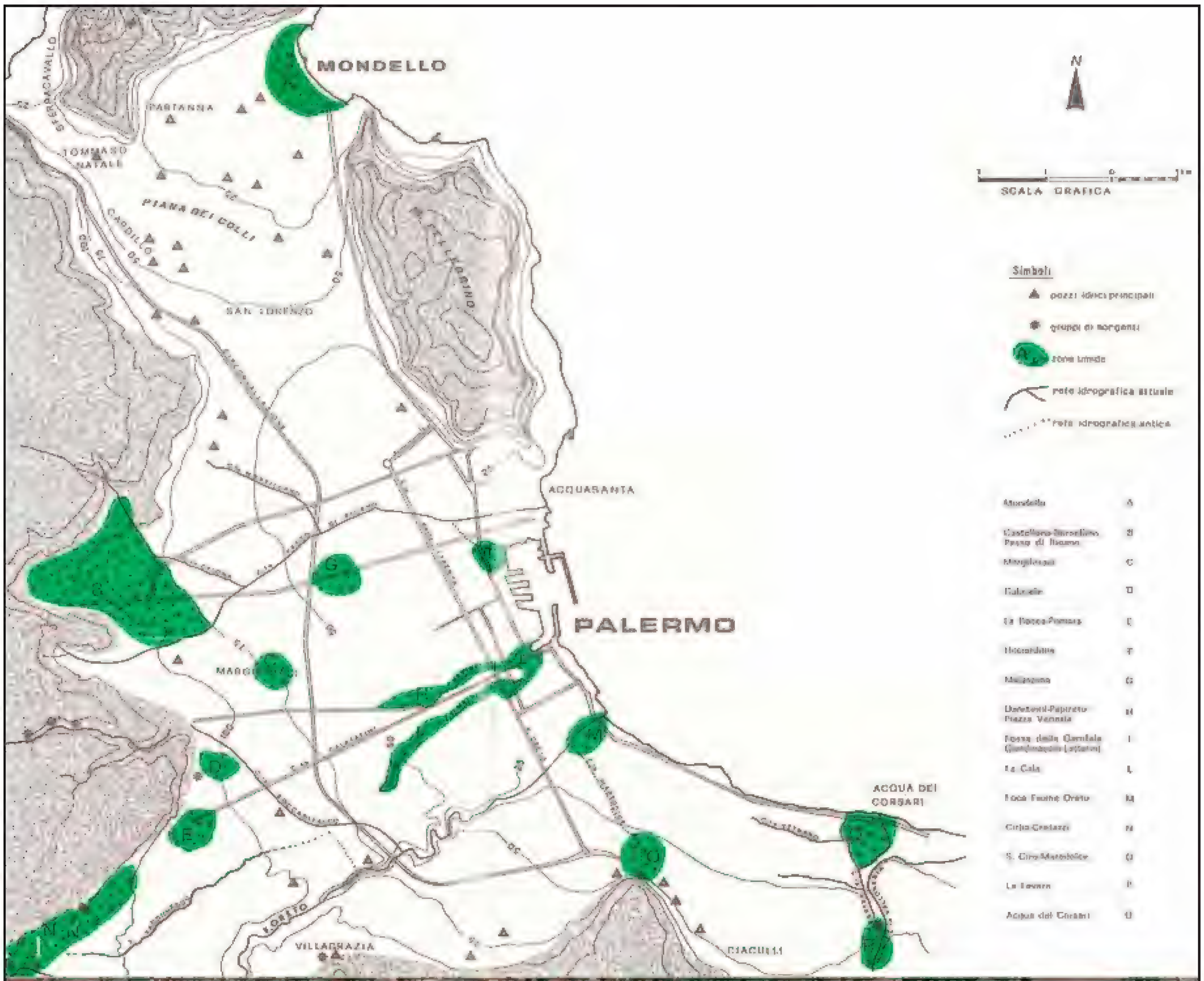
Freshwater snails, shells and live specimens, were sampled on sight in the natural and artificial waters of the study area and by using little nets and sorting variable amount of sediment.

Unrelaxed material preserved in 75% ethanol, was studied by Optika light microscope. Soft parts were isolated and dissected using very fine, pointed watchmaker's forceps. Images of the body and the genitalia were drawn using a camera lucida. Habitat, shells and live specimens were photographed by using a Canon EOS 100D.

The main morphological and anatomical characters have been described to document these populations living in a relict and threatened area.

Taxonomical references are based on the checklist of the fauna europea (Bank, 2011) and other cited papers.

Anatomical acronyms: BC: bursa copulatrix; DBC: duct of the bursa copulatrix; MP: muscle plica; P: penis; PA: penial apex; PAD: penial accessory duct; PG: preputial gland; PL: penial lobe; PR: prostate; PRM: penial retractor muscle; PRP: preputium; PS: penial sheath; SLS: sucker-like structure; SM: supporting muscles; VD: vas deferent.


1
MONDELLO
N
PARTANNA
TOMMASO NATALE
PIANA DEI COLLI
CARDILLO
SAN LORENZO
SFERRACAVALLO
ACQUASANTA
PALERMO
ACQUA DEI CORSARI
VILLAGRAZIA
CIACULLI
SCALA GRAFICA
Simboli
pozzi idrici principali
gruppi di sorgenti
zone umide
rete idrografica attuale
rete idrografica antica
Mondello A
Gabriele D
Malaspina G
Danisinni-Papireto Piazza Venezia H
La Cala L
Foce Fiume Oreto M
S. Ciro-Maredolce O
La Favara P
Acqua dei Corsari Q

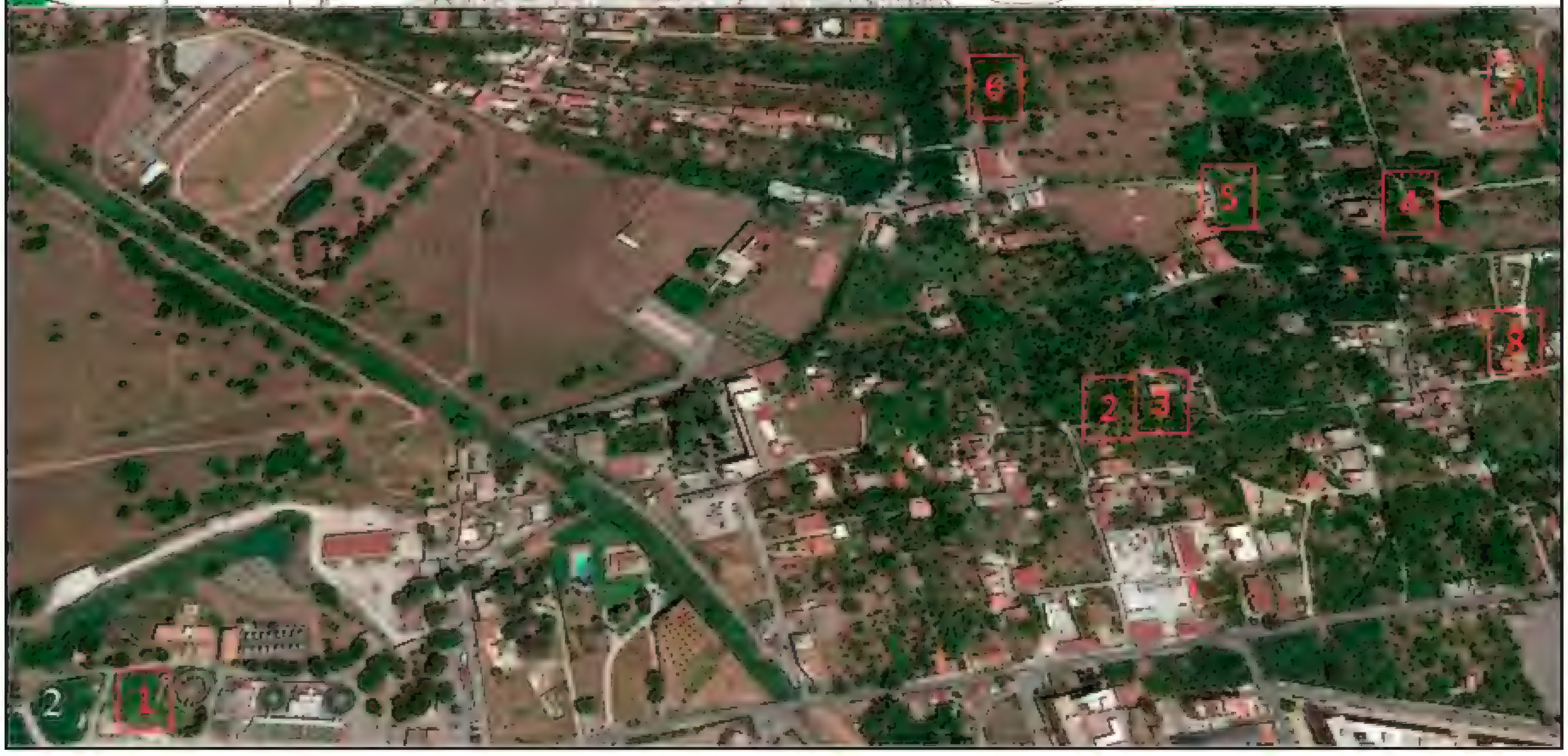


Figure 1. Freshwater environment in the Palermo surrondings (by Cusimano et al., 1989 modified). Figure 2. Study area. 1: Gabriele's springs; 2: Gebbia Fratelli La Mantia; 3: Saje Fondo Micciulla; 4: Gebbia under the walls of Villa Belvedere; 5: Gebbia at the boundary wall of the Santacolomba fund; 6: "Due gebbie" the Santacolomba fund; 7: Camera dello Scirocco (Room of Sirocco): Qanat Scibene e Qanat Savagnone; 8: Qanat Gesuitico Alto.

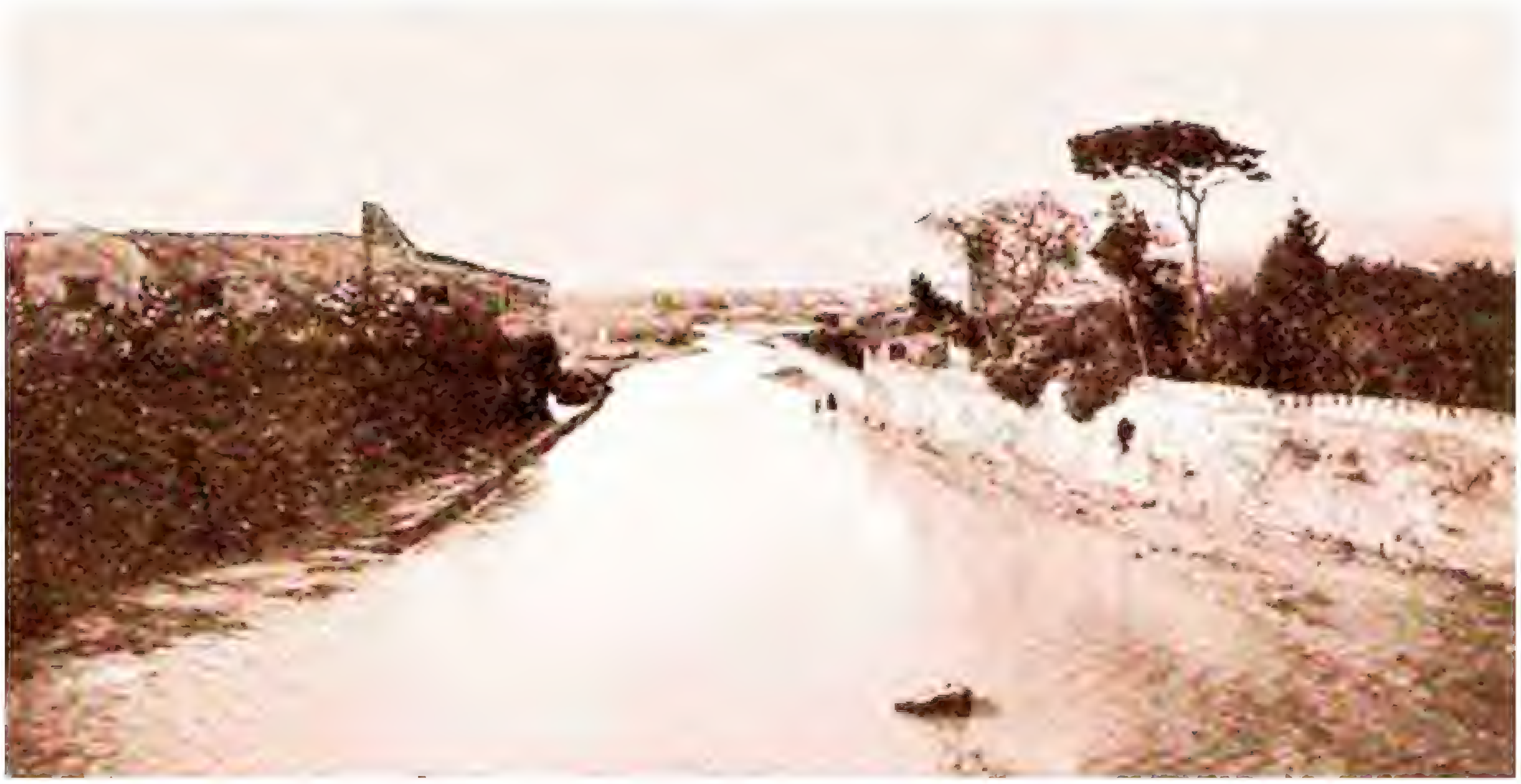
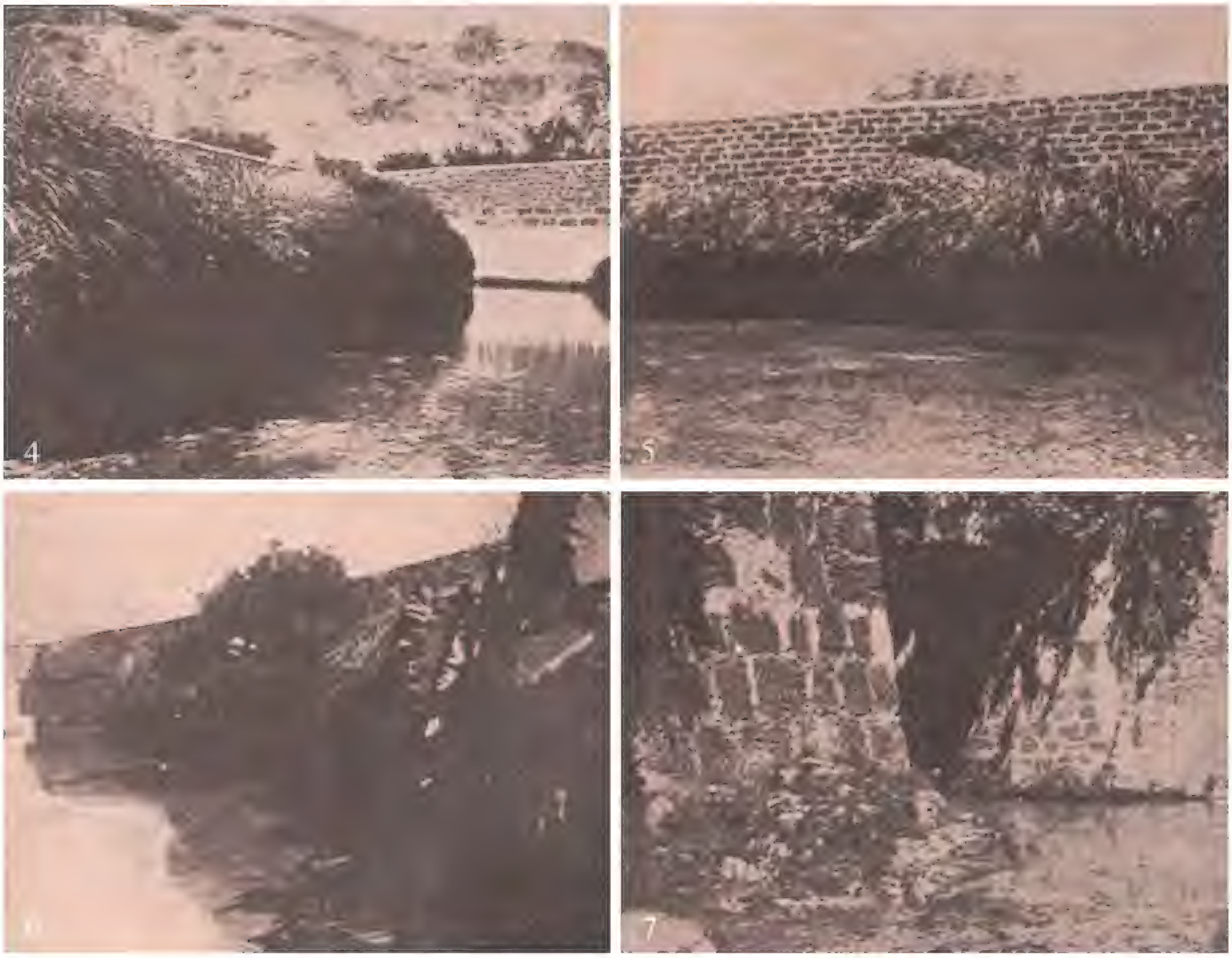


Figure 3. Oreto River near Palermo (by Lojacono, 1931 modified).



Figures 4-7 (by Carapelle, 1914). Gabriele's springs around 1900. Figs. 4, 5: Nixio springs. Fig. 6: the aqueduct for the Palermo city (Nixio springs). Fig. 7: Connection of the freshwaters of Cuba spring with those of Gabriele spring.

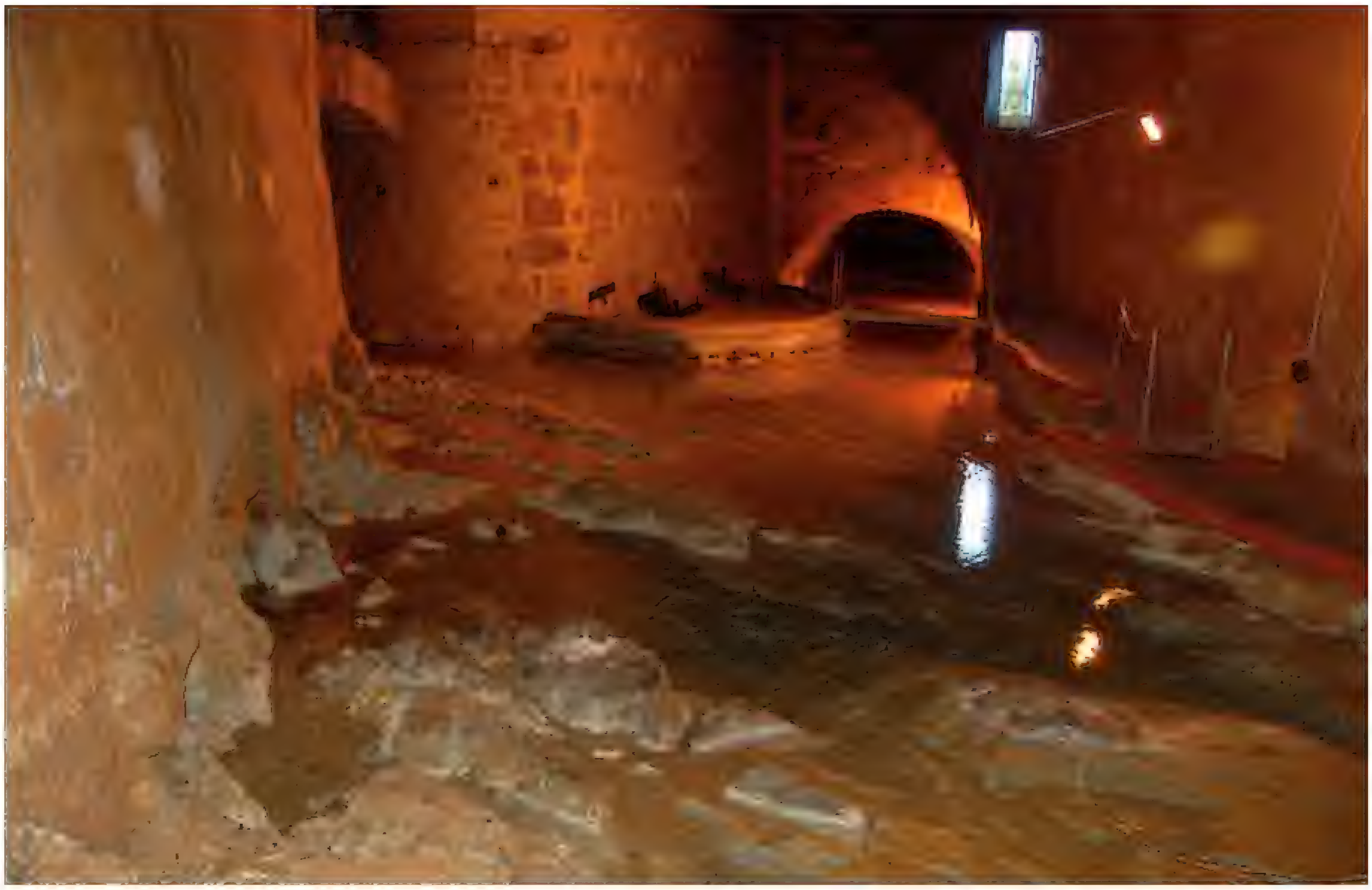


Figure 8. Gabriele's springs, to our day (2015).

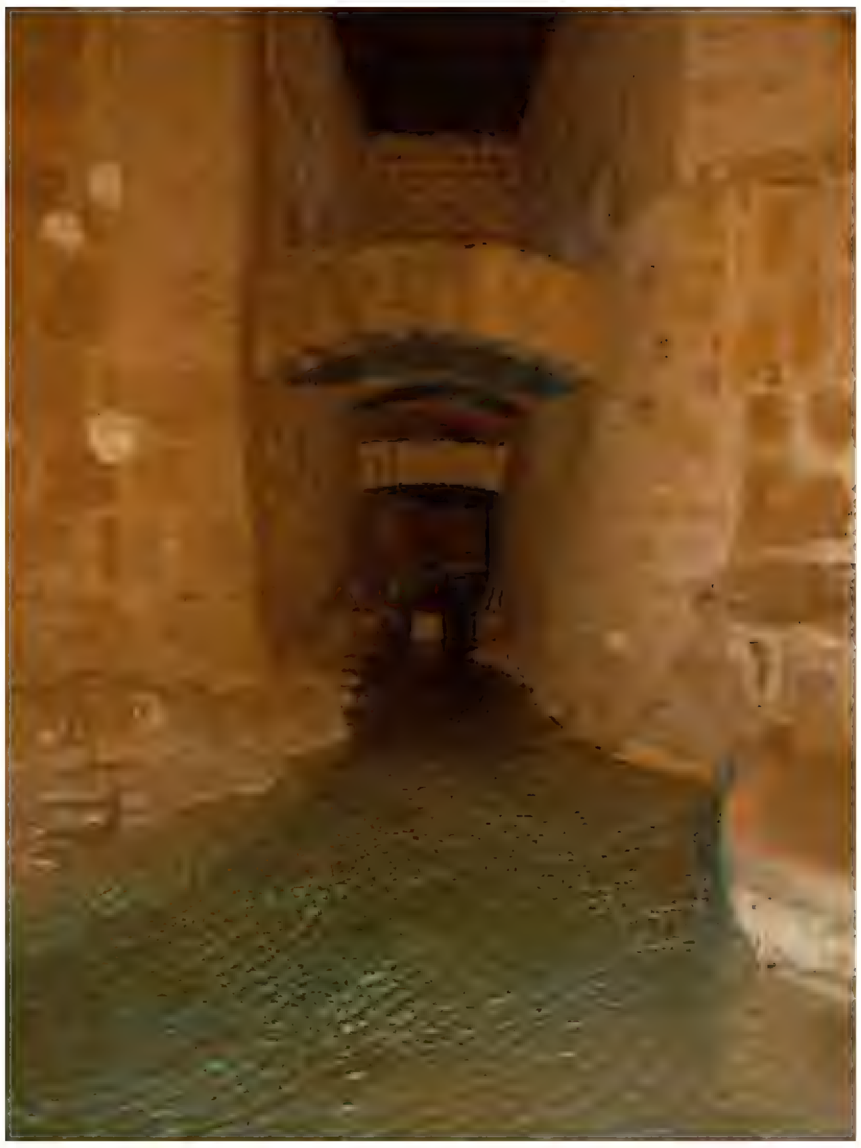


Figure 9. Detail of the Gabriele springs, now covered by an ancient structure.

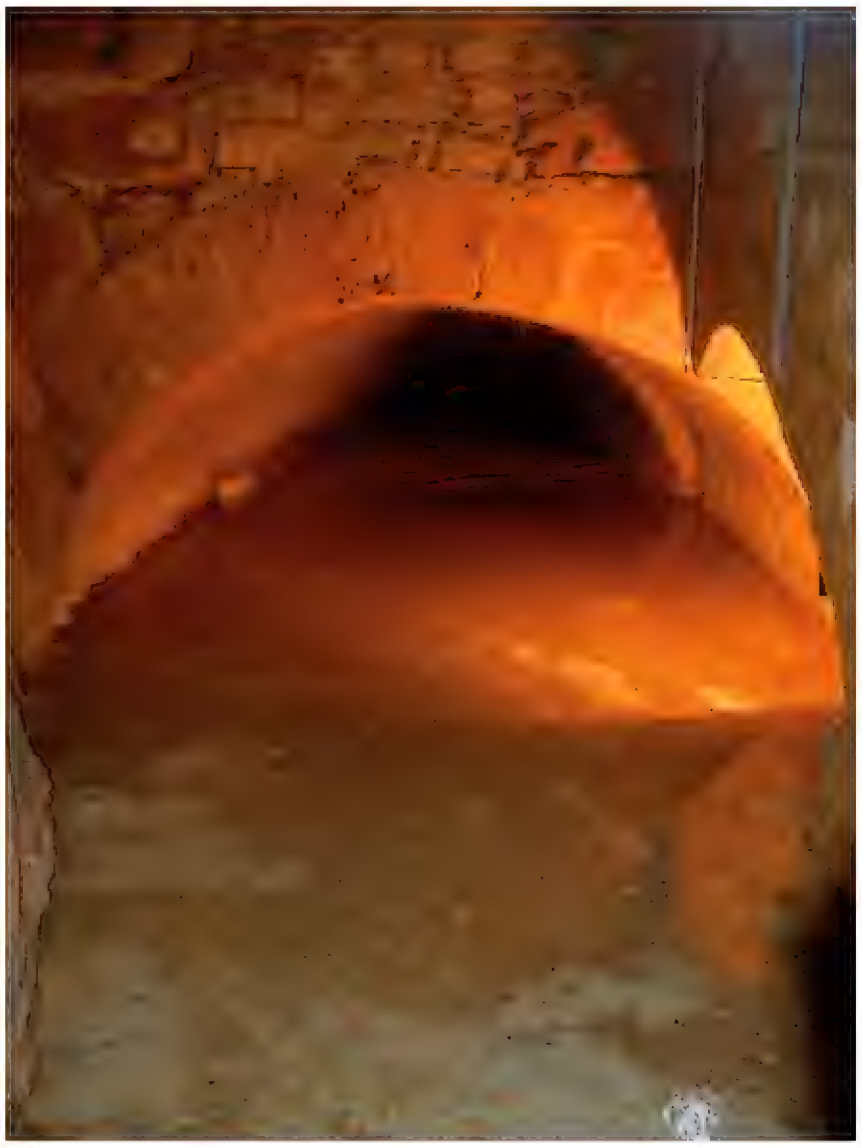
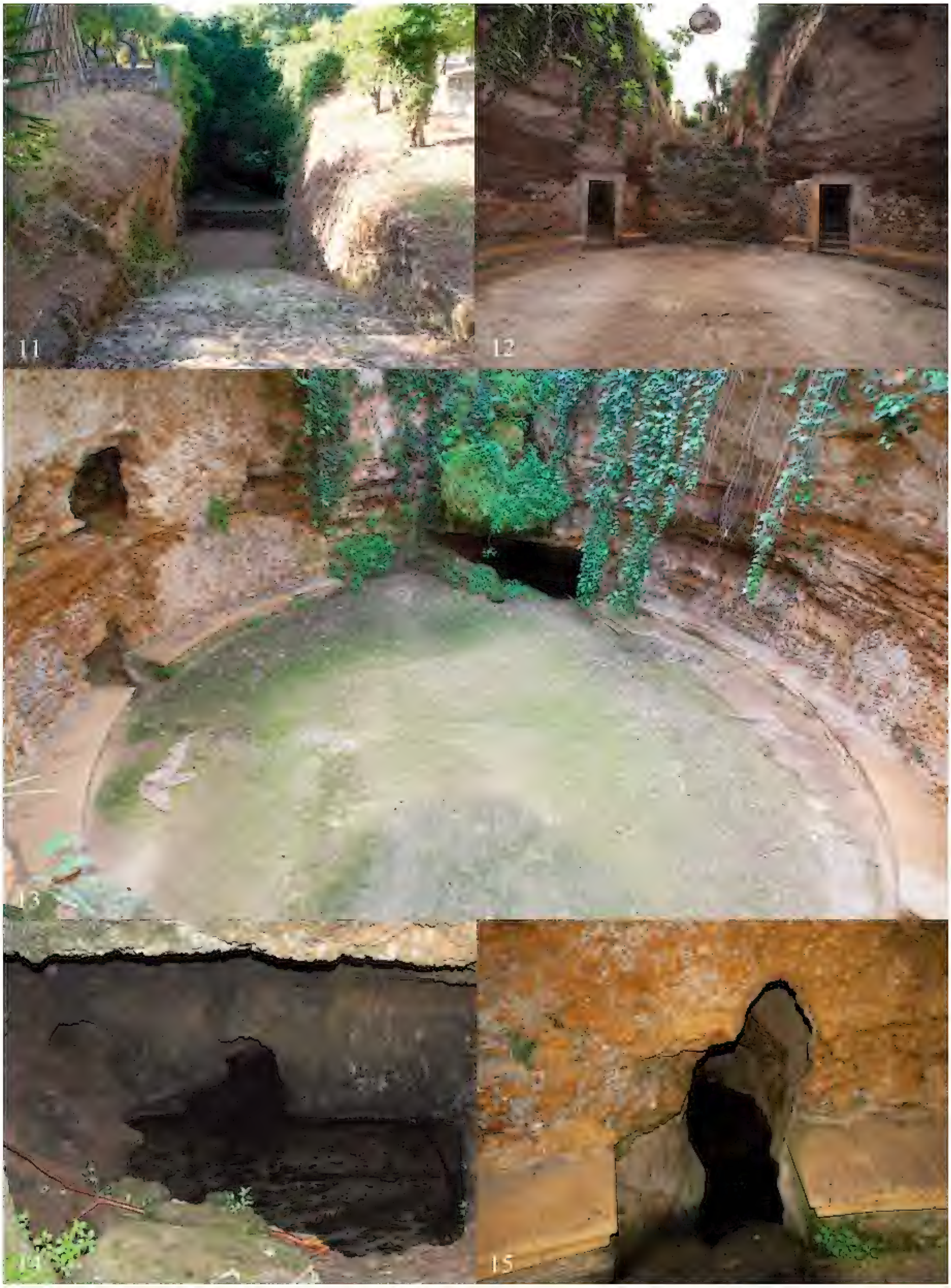


Figure 10. Detail of the Gabriele springs, now covered by an ancient structure.



Figures 11-15. Villa Savagnone's "Camera dello Scirocco" (Room of Sirocco). In figure 13 it can be seen the entrance of the Qanat Scibene to the right (see also Fig. 14) and the entrance of the Qanat Villa Savagnone (Fig. 15).

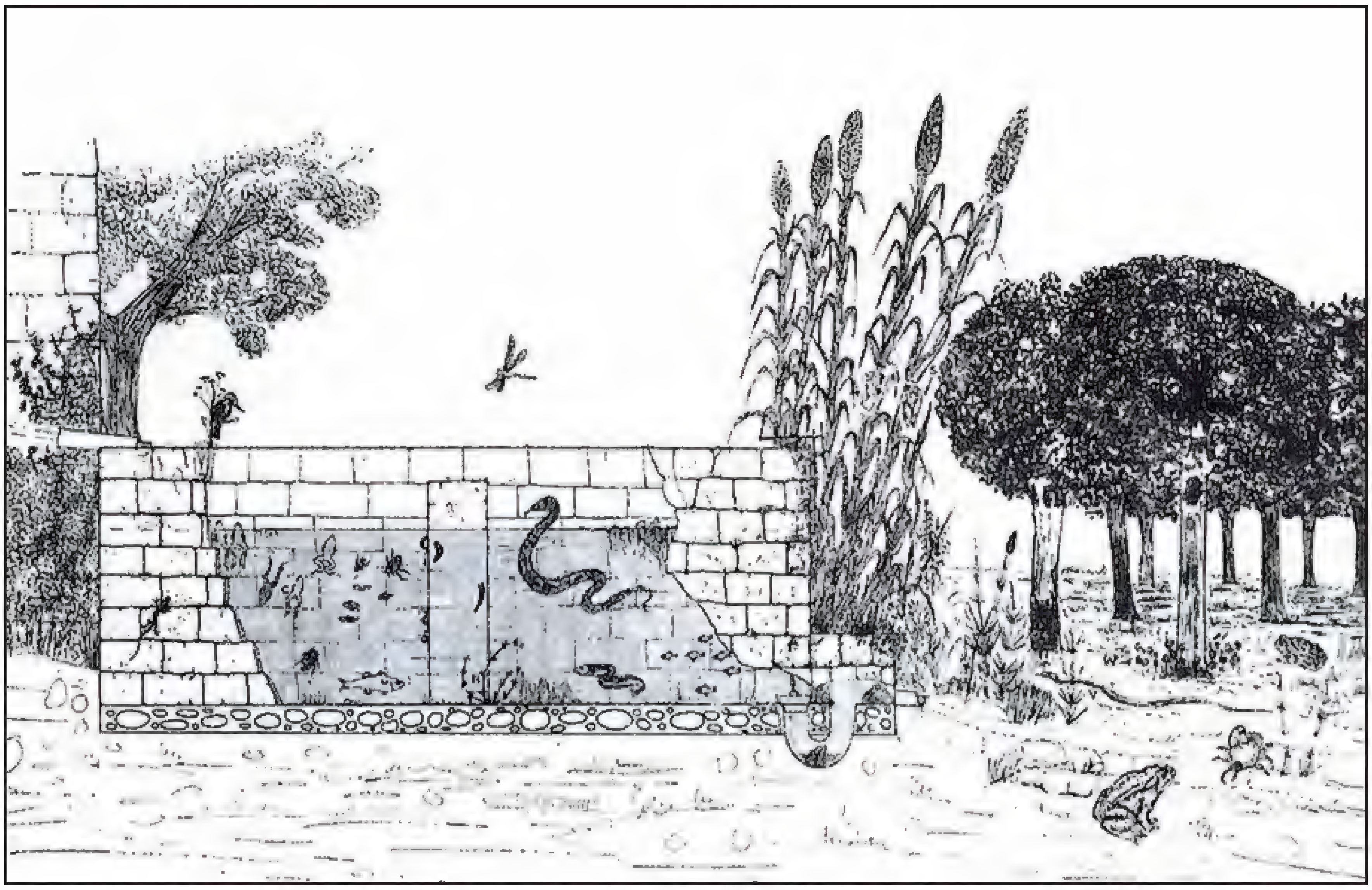


Figure 16. Ecological scheme of a Gebbia in the Palermo Plain (by Riggio, 1976 modified).

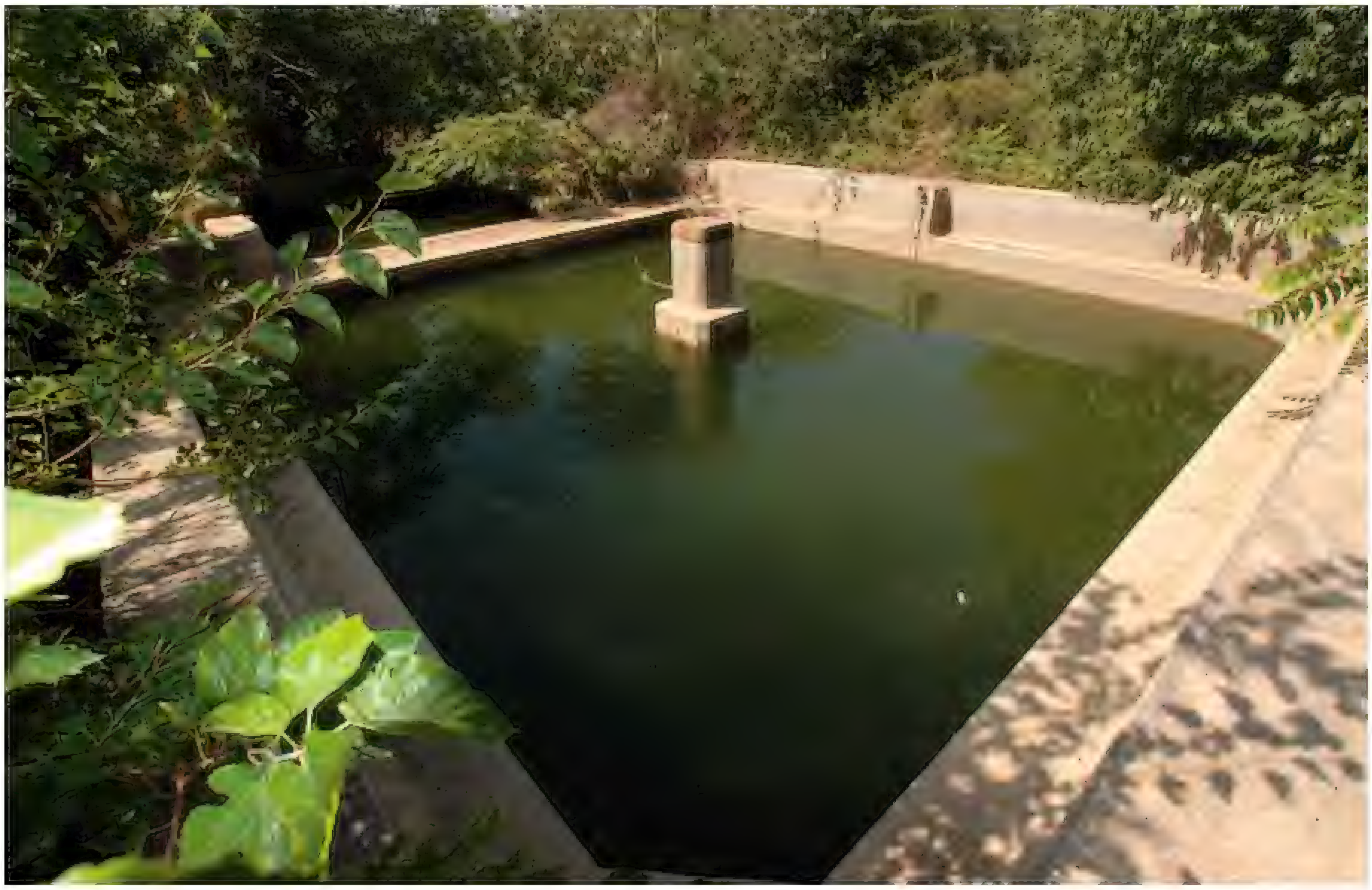


Figure 17. “Ru gebbi” (two gebbie) at Fondo Santacolomba formed by two intercommunicating water tanks.

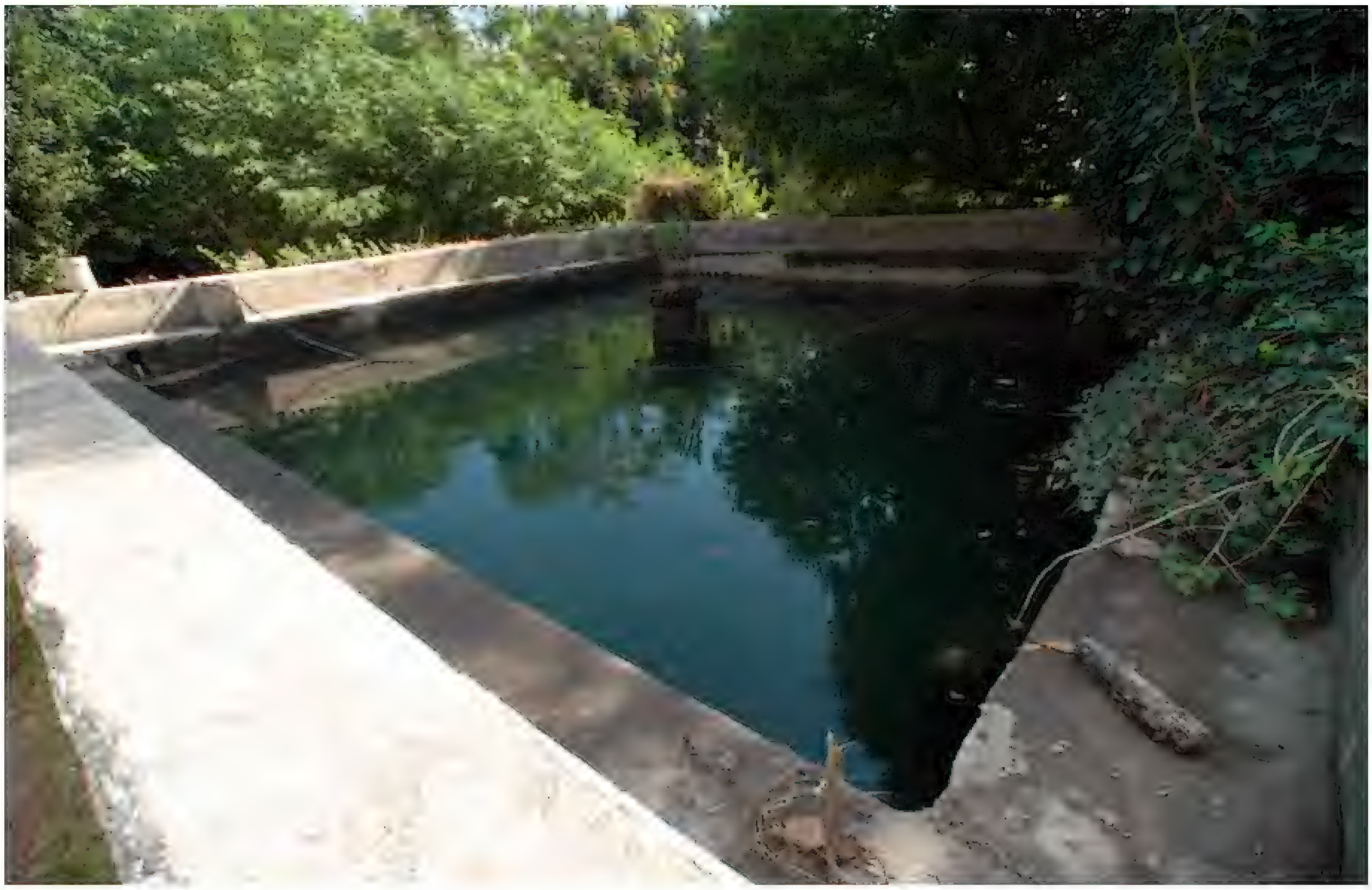


Figure 18. Gebbia under the walls of Villa Belvedere (Fondo Santacolomba).

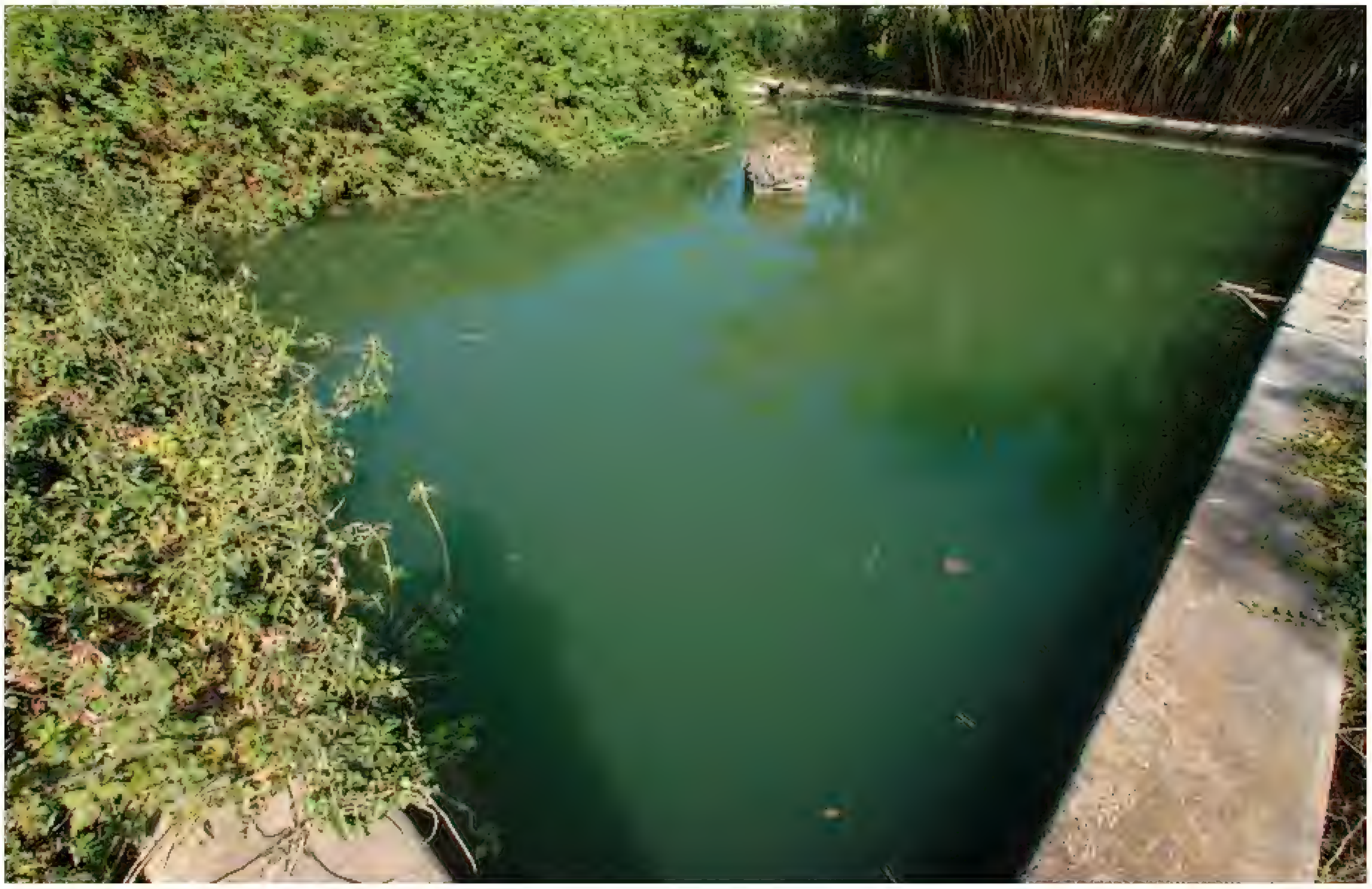


Figure 19. Gebbia at the boundary wall of the Fondo Santacolomba.

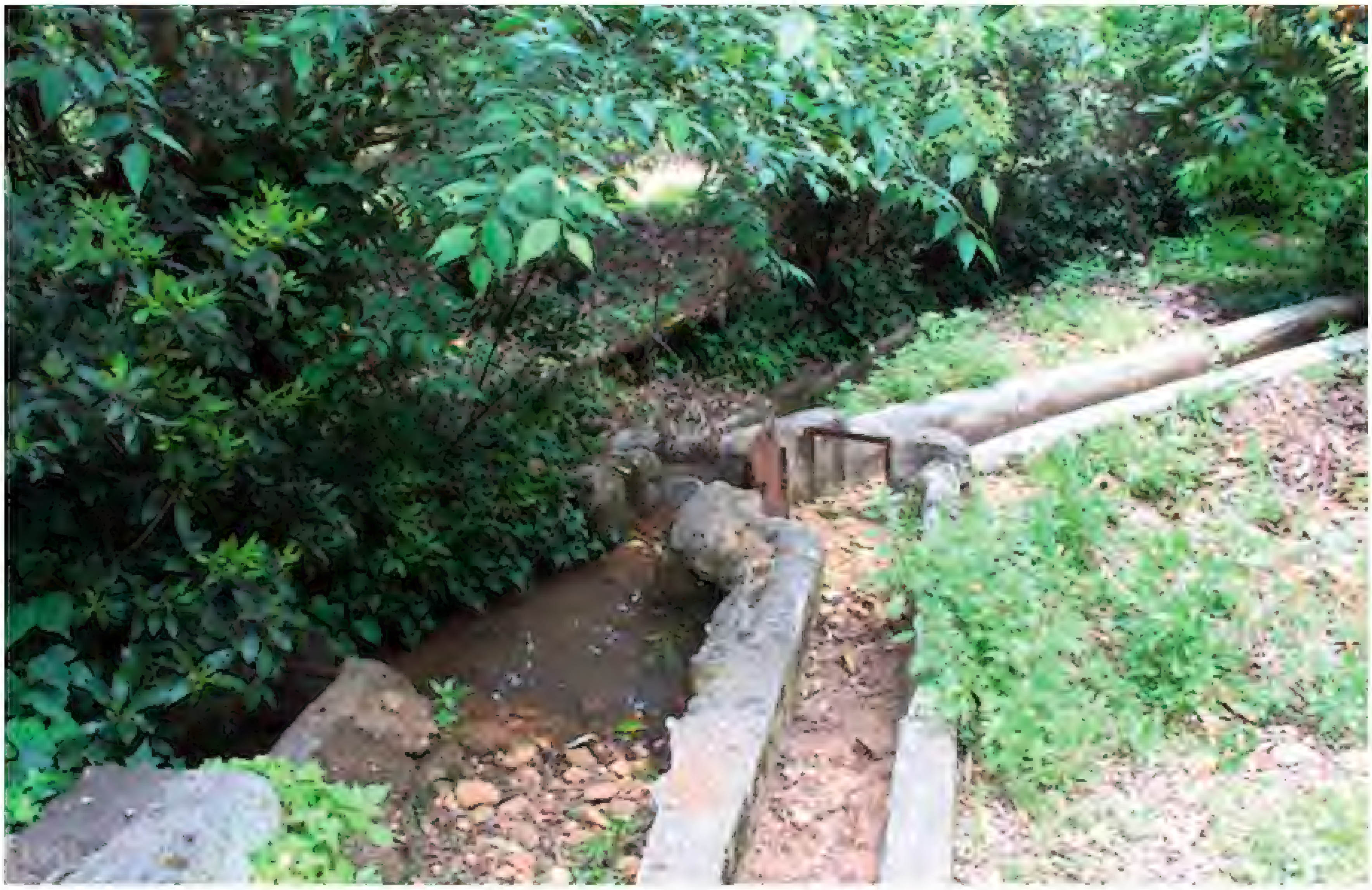


Figure 20. Saja located in Fondo Micciulla.

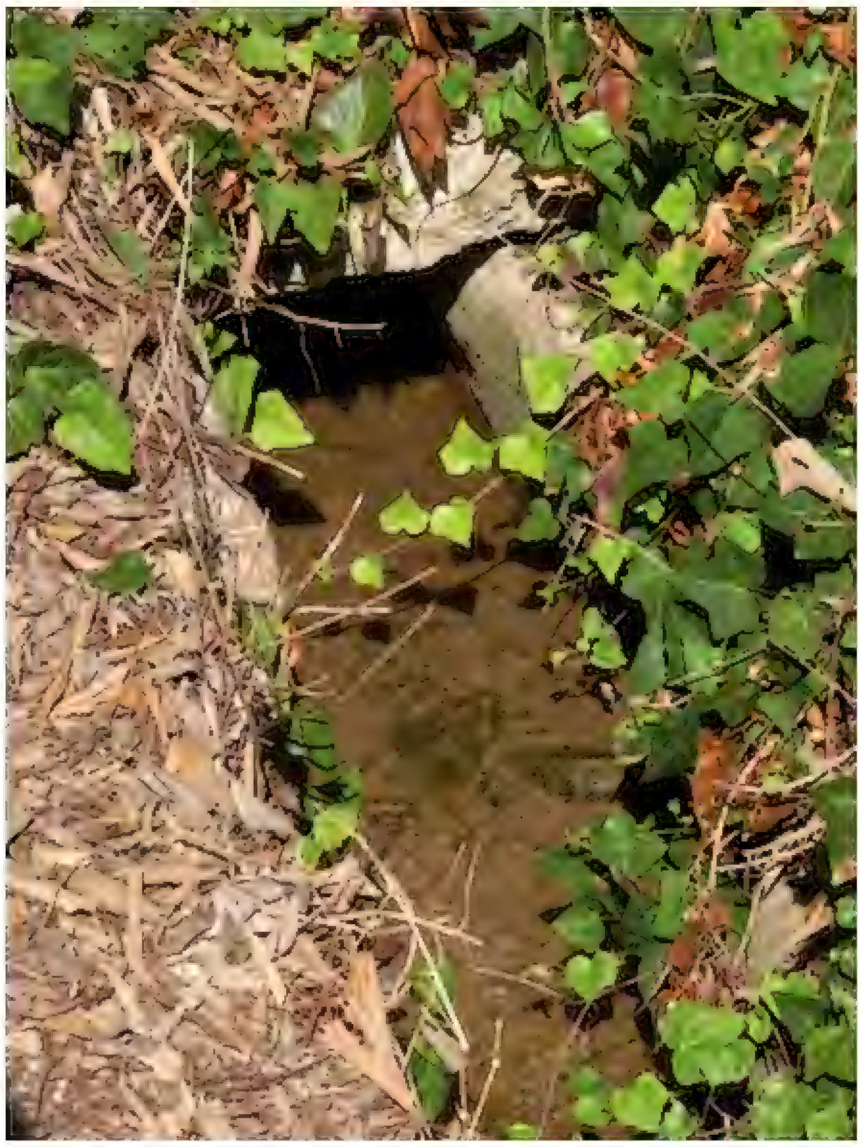


Figure 21. Detail of the saja located in Fondo Micciulla with the continuous presence of water.

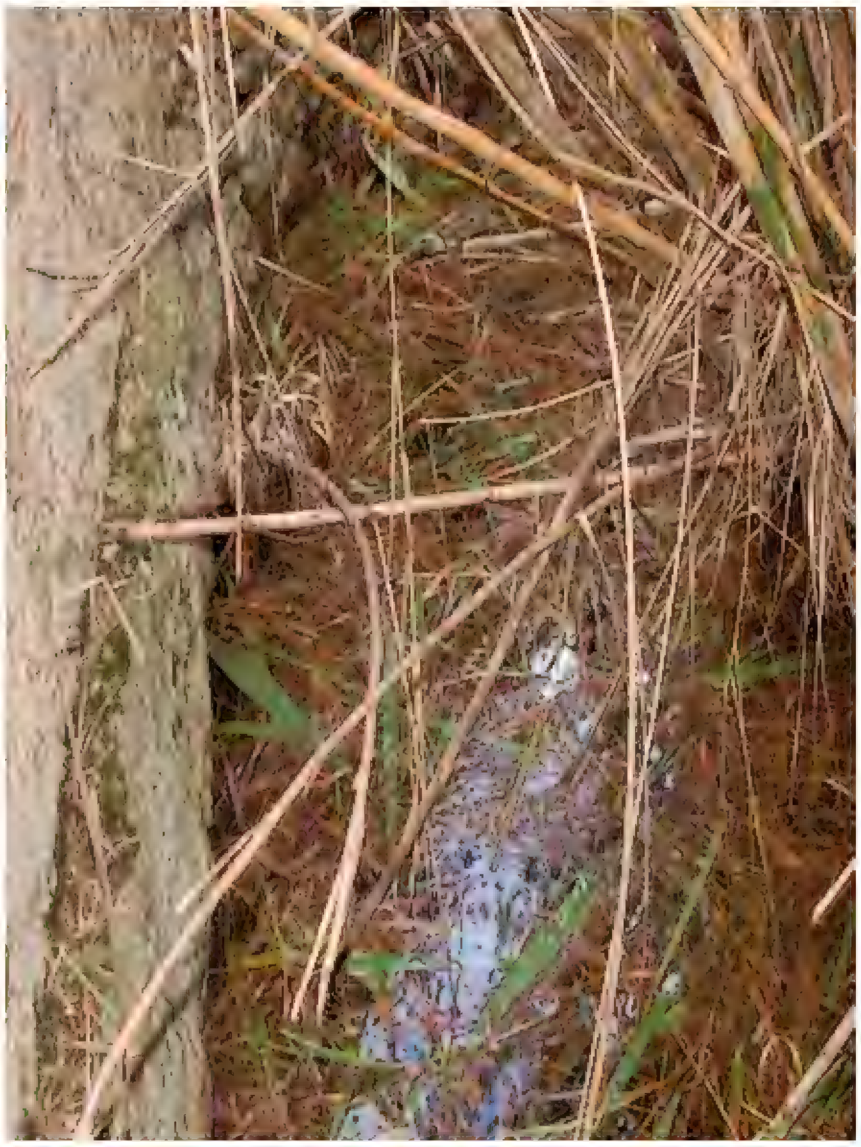


Figure 22.The Source of "Fontane" overgrown by *Arundo donax*.

RESULTS

Systematics

Class GASTROPODA Cuvier, 1795
Subclass ORTHOGASTROPODA Ponder et Lindberg, 1995
Superordo CAENOGASTROPODA Cox, 1960
Ordo NEOTAENIOGLOSSA Haller, 1882
Superfamilia RISSOOIDEA Gray, 1847
Familia BITHYNIIDAE Gray, 1857
Genus *Bithynia* Leach, 1818

Bithynia cf. ***leachii*** (Sheppard, 1823)

Description. Shell dextral (Fig. 35), conical, elongated, moderatly robust, gray-blackish-gray in colour; height 4.9–5.7 mm, maximum diameter 3.5–4.2 mm, aperture height 2.4–3.2 mm, aperture diameter 2.2–2.9 mm; external surface with thin growth lines, spire formed by 4–5 convex whorls with a deep sutures; apex rounded; aperture subcircular, little elongated; peristome simple and continuous; operculum with thin growth lines and nucleus eccentric.

Distribution and Biology. Paleartic. *Bithynia leachii* is widespread through Italy (Girod et al., 1980; Bodon et al., 1995, 2005) and lives in different habitats, such as rivers, streams, etc.

Status and Conservation. *Bithynia leachii* is classified Least Concern (LC) by Cuttelod et al. (2011) and in IUCN Red List (Vavrova et al., 2010).

Remarks. This species was reported for this study area by Calcara (1845 sub *Paludina rubens*: "*alle sorgive del Gabriele*"), see also Bodon et al. (2005).

Sicilian populations need a systematic reassessment (Bodon et al., 1995) but in sampling for this work we did not find live specimens. Some preliminary data for a population from south-eastern Sicily (Irminio River) seem to show a morphological and anatomical difference (flagellum very short) by comparition with other Italian populations (Bodon *in litteris*).

Many taxa have been described for the populations of Sicilian *Bithynia*, that, currently, are considered synonyms of *B. leachii* (Alzona, 1971).

Familia HYDROBIIDAE Stimpson, 1865
Subfamilia BELGRANDIINAE De Stefani, 1877
Tribus ISLAMIINI Radoman, 1983
Genus *Islamia* Radoman, 1973

Islamia pusilla (Piersanti, 1952)

Description. Shell dextral (Fig. 23), valvatoid, not depressed, transparent and whitish-waxen when fresh, sometimes encrusted; height 0.8–1.5 mm, maximum diameter 0.9–1.2 mm, aperture height 0.57–0.7 mm, aperture diameter 0.6–0.8 mm; external surface of shell with thin growth lines; spire little pointed, raised, with 2.5–3 1/4 convex and rapidly expanding whorls; last whorl very wide, little descending near aperture; suture deep; umbilicus open, wide 1/7–1/8 of maximum shell diameter; aperture large and sub-circular; peristome continuous, juxtaposed to the last whorl wall, slightly thickened, slightly reflected at its inferior margin, not sinuous at its external margin. Operculum paucispiral, thin, yellow-orange pale.

Body (Fig. 24): mantle more or less pigmented, blackish; the head is little pigmented; penis non pigmented.

Genitalia. *Islamia pusilla* investigated are characterized by: apical portion of penis more or less markledy bilobate (Fig. 25); right portion, more slender, obtuse and projecting further forward, constituting tip of penis; left portion forms the so-called penial lobe; penial lobe slightly protruding to apical portion of penis; muscle plica on the ventral surface of the penis well developed but not projecting on the left side. Female genitalia with two seminal receptacles.

Distribution and Biology. *Islamia pusilla* is endemic to Italy, specifically found in the appenninic regions (Tuscany, Lazio, Campania, Puglia, Molise, Abruzzo) and in Sicily, but localised (Giusti & Pezzoli, 1980; Bodon et al., 2005; Bodon & Cianfanelli, 2012).

This species lives in springs.

Status and Conservation. *Islamia pusilla* is classified as "Least Concern" in IUCN Red List (Cianfanelli et al., 2010a) and by Cuttelod et al. (2011).

Remarks. The two populations of *I. pusilla* found in the study area (Table 1) do not show substantial morphological differences between them, except for a darker pigmentation of the body and shell more encrusted than those living in a more open environment such as the water tank at the Gabriele Spring.

Subfamilia HYDROBIINAE Stimpson, 1865
Genus *Pseudamnicola* Paulucci, 1878

Pseudamnicola (Pseudamnicola) moussonii moussonii (Calcara, 1841)

Description. Shell dextral, conical-ovoidal but very variable in height and roundness, brownish or black-greyish in colour, often encrusted and corroded; height 3–5.1 mm, maximum diameter 2.5–3.2 mm, aperture height 1.8-2.6 mm, aperture diameter 1.4–2.1 mm; external surface smooth with thin growth lines; spire formed by 3.5–4 convex whorls; last whorl 3/4–4/5 of shell height; sutures deep; umbiculus open; aperture oval; peristome continuous, non thickened, slightly reflected at lower and columellar margins. Operculum with thin growth lines and nucleus eccentric.

Body (Fig. 26) well pigmented in black; pallial cavity open, gill present; lobes present.

Male genitalia with penis cilindrical, elongated (Fig. 27), black pigmented; penis tip blunt with a few wide folds on side and vas deferens opening at apex. Female genitalia with renal oviduct pigmented black; gonopericardial duct present; seminal receptacle variably elongated; bursa copulatrix duct long and slender and straight to twisted; bursa copulatrix large, triangular; pallial oviduct with albumen gland runned ventrally by sperm channel and capsule gland.

Distribution and Biology. The genus *Pseudamnicola* has a Mediterranean distribution. To *P. moussonii* refer different and distinct populations widespread on the Western Mediterranean (see also Giusti & Pezzoli, 1980; Bodon et al., 1995; Giusti et al., 1995). This freshwater snail is found in springs, water trough, rivers and running freshwater, on rocky and sandy substrata, often aggregating on plants.

Status and Conservation. This species is classified as “Least Concern” in IUCN Red List (Cianfanelli et al., 2010b) and by Cuttelod et al. (2011).

Remarks. *Pseudamnicola moussonii* is very frequent in Sicily, and it varies in the shape and size of the shell (Fig. 28, 29) and in some anatomical characters such as the length of the seminal receptacle.

In the study area the population of the tank near the Gabriele Spring has the seminal receptacle longer than that of the population from the spring of the Room of Sirocco.

Pseudamnicola moussonii was described by Calcara (1841) from Sicily (locus typicus: “*Trovasi nelle vicinanze della Piana dei Greci ... Lago di Dingoli*”); for the proper placement of the locus typicus see Liberto et al. (2010).

Other species of Sicilian *Pseudamnicola* are *P. sciaccaensis* Glöer et Beckmann, 2007, which is at the time endemic (Glöer & Beckmann, 2007, locus typycus: “*Brunnentrog an der Straße von Menfi nach Sciacca, Sizilien, Italien*”) and *P. orsinii* (Küster, 1852) probably endemic to Italy (Bodon et al., 2005).

Subfamilia TATEINAE Thiele, 1925
Genus *Potamopyrgus* Stimpson, 1865

Potamopyrgus antipodarum (J.E. Gray, 1843)

Description. Shell dextral (Fig. 36), elongated, grayish, yellowish, dark-brownish in colour, often encrusted; height 4.2–5.3 mm, maximum diameter 2.2–3 mm, aperture height 2.1–2.5 mm, aperture diameter 1.8–2 mm; external surface with thin growth lines; spire formed by 5–7 convex whorls; last whorl 2/3 of shell height, a specimen with a thin and interrupted keel; sutures little deep; umbilicus closed; aperture oval; peristome continuous, non thickened, detached from the last whorl; operculum paucispiral, thin and corneus.

Body black in colour, particularly head, tentacles, and mantle; pallial cavity open, gill present; operculigerous lobes present.

Female genitalia with bursa copulatrix small and oval; seminal receptacle small with long and slender duct; pallial oviduct with albumen gland, sperm channel and capsule gland.

Distribution and Biology. *Potamopyrgus antipodarum* (New Zealand mud snail, Jenkins’ Spire Snail) is native to New Zealand and adjacent islands and it has been introduced to Europe, Iraq, Turkey, Japan, the Americas and Australia (Ponder, 1988; Kerans et al., 2005). It is present also in Italy, including Sicily (Berner, 1963; Favilli et al., 1998; Cianfanelli et al., 2007; Colomba et al., 2013).

It is a species with great ecological value, which lives in both sweet and brackish waters, lotic and lentic environments, on rocks, gravel, mud, organic debris and vegetation. This allochthonous species has a fast spread, tolerates discrete pollution and is often present with numerous populations. In Europe, *P. antipodarum* causes declines in species richness and abundance of native snails in constructed ponds (Strzelec, 2005).

STATUS AND CONSERVATION. This species is classified as "Not Applicable" by Cuttelod et al. (2011) and as "Least Concern" in I.U.C.N. Red List (Van Damme, 2013).

REMARKS. *Potamopyrgus antipodarum* is variable in the shell morphology, with a keel in the middle of each whorl that may be completely absent, periostracal ornamentation, umbilicus sometimes little open, etc. (Favilli et al., 1998; Hosea & Finlayson, 2005).

Normally, both sexual and asexual reproduction coexists but non-native populations of this species are parthenogenetic and consist almost exclusively of females (Jokela et al., 1997; Alonso & Castro-Díez, 2008). *Potamopyrgus antipodarum* is ovoviviparous, and females brood their offspring in a brood pouch until they reach the "crawl-away" developmental stage (Jokela et al., 1997).

Only two living females and eight shells were observed; they were found in the Qanat "Gesuitico Alto" completely underground and aphotic (Table 1).

This allochthonous and invasive species is rapidly increasing in sicilian natural waters and is already present with numerous populations in several natural localities such as the Belice River and Ciane River.

Superordo HETEROBRANCHIA J.E. Gray, 1840
Ordo PULMONATA Cuvier in Blainville, 1814
Subordo BASOMMATOPHORA Keferstein in Bronn, 1864
Superfamilia LYMNAEOIDEA Rafinesque, 1815
Familia LYMNAEIDAE Rafinesque, 1815
Subfamilia LYMNAEINAE Rafinesque, 1815
Genus *Galba* Schrank, 1803

Galba truncatula (O.F. Müller, 1774)

DESCRIPTION. Shell dextral (Figs. 42, 43), conical, oblong, rounded apex; brown or reddish-brown in colour, often encrusted and corroded; height 6.5–8.3 mm, maximum diameter 4–5.8 mm, aperture height 4.4–6.2 mm, aperture diameter 3–4.6 mm; external surface with thin growth lines, spire with 4–6 convex and regular whorls; last whorl large, 3/3 of shell height; sutures deep; umbilicus little open partially covered by columellar margin of peristome; aperture oval and oblique; peristome simple, interrupted.

Body yellow-greyish, tentacles triangular with eyes on internal basal vertex, mantle surface with very little light spots.

Genitalia characterized by preputium 3 times as long as penis sheath; penis short and slender; long and slender bursa copulatrix duct; seminal vesicles consisting of many long, slender, digit-like diverticula on both sides of first hermaphrodite duct.

DISTRIBUTION AND BIOLOGY. Holarctic. This species is reported throughout Italy (Girod et al., 1980; Manganelli et al., 1995).

Galba truncatula is found in stagnant or slow-moving freshwaters, natural and artificial. It is also tolerant of poor water quality, polluted or muddy waters, and it is able to colonize temporary ponds. It is common in Sicily.

STATUS AND CONSERVATION. It is classified as "Least Concern" by Cuttelod et al. (2011) and in I.U.C.N. Red List (Seddon et al., 2015).

REMARKS. *Galba truncatula* is not common in the examined territory, and it is found with several living specimens in some Micciulla irrigation canals and in the Gebbia Santacolomba

Genus *Radix* Montfort, 1810

Radix auricularia (Linnaeus, 1758)

Description. Shell dextral (Figs. 37, 38), inflated, subtransparent, yellowish-brown in colour with sometimes encrusted; height 16–23.2 mm, maximum diameter 11.5–17.5 mm, aperture height

12–18 mm, aperture diameter 8–13 mm; external surface with thin growth lines; apex pointed; spire with 4 convex whorls, the last very large and convex, inflated, equal to 5/6 of shell height; sutures are shallow, only in the last whorl deep; aperture very large, ear-shaped; peristome thin, reflected; columellar margin folded on the umbilicus which is little visible.

DISTRIBUTION AND BIOLOGY. This species is a widespread palearctic species present through much of Europe and into north Asia, introduced throughout the United States. *Radix auricularia* is reported throughout Italy by Girod et al. (1980) but not in Sicily (Cossignani & Cossignani, 1995; Manganelli et al.,1995).

It is found in stagnant or slow-moving freshwaters, even artificial, as reservoirs, fountains, irrigation canals, “gebbie”.

STATUS AND CONSERVATION. This species is considered “Least Concern” by Cuttelod et al. (2011) and in IUCN Red List (Seddon et al., 2014).

REMARKS. Only a few shells referred to *R. auricularia* have been found in the territory of Micciulla, near “Ru gebbie” and Gebbia Villa Belvedere (Table 1).

Genus *Stagnicola* Jeffreys, 1830

Stagnicola fuscus (C. Pfeiffer, 1821)

Description. Shell dextral (Figs. 40, 41), elongated, relatively robust, with pointed apex; brown-reddish in colour; height 11.8–17.8 mm, maximum diameter 6–9.8 mm, aperture height 7–10 mm, aperture diameter 4.5–7 mm; external surface with spiral striae which cross-cut the radial growth striae that form a square ornamentation, whorls 6–7 not very convex, sutures little deep, umbilicus closed, aperture oval, elongated, height about 1/3 of shell height.

Body grey-dark in colour with very little and yellowish spots (Fig. 39); tentacles short and subtriangular, wide at the base and rounded to the apex, and with eyes at base; foot long, rounded anteriorly and pointed posteriorly.

Genitalia characterized by a short praeputium (slightly shorter than the penis) and two prostate folds (in the internal lume of the prostate) (Fig. 30).

DISTRIBUTION AND BIOLOGY. Distribution to be reviewed, because many reports for *S. fuscus* were attributed to *S. palustris* (O.F. Muller, 1774) (Girod et al., 1980; Manganelli et al., 1995). In Sicily *S. fuscus* is reported by Beckmann & Falkner (2003) on anatomically determined specimens from Palermo, Anapo River at Floridia and Siracusa. This species is also reported in the British Isles by Carr & Killeen (2003) and Glöer & Yıldırım (2006) assume that all Southern European *Stagnicola* probably belong to *S. fuscus*; on this wiev, see also Pavon & Bertrand (2005) for southern France and Soriano et al. (2006) for Catalonia.

Stagnicola fuscus is common in Sicily in running and slow-moving waters, even artificial, usually with rich vegetation.

STATUS AND CONSERVATION. It is considered “Least Concern” by Cuttelod et al. (2011) and in IUCN Red List (Seddon, 2011).

REMARKS. *Stagnicola fuscus* is found at Micciulla in some irrigation canals rich in vegetation fed by a “gebbia” inside an old citrus grove. Calcara (1845) reports “*Limnaeus palustris*” from Boccadifalco, a neighboring area at Micciulla.

Correa et al. (2010) proposed that species of clade C2 of their paper, including *S. fuscus*, *S. palustris* (type species of *Stagnicola)* and *L. stagnalis* Linnaeus, 1758 (type species of *Lymnaea*) should all be called *Lymnaea*, according to the principle of priority of the International Code of Zoological Nomenclature (ICZN). *Stagnicola fuscus* would be named *Lymnaea fusca* C. Pfeiffer, 1821.

Superfamilia PLANORBOIDEA Rafinesque, 1815
Familia Physidae Fitzinger, 1833
Genus *Physella* Haldeman, 1842

Physella acuta (Draparnaud, 1805)

DESCRIPTION. Shell sinistral, ovoidal-fusiform, glossy, sub-transparent, with pointed apex, pale yellowish-brown or reddish-brown in colour; height 8.2–11 mm, maximum diameter 5–10 mm, aperture height 6.7–7.6 mm, aperture diameter 3.8–4.8 mm; external surface with very thin growth lines; spire with 5–6 regularly growing whorls; last whorl large, about 2/3 of shell height; the sutures are shallow, olly in the last whorl deep; umbilicus closed; aperture ovoidal-elongated, slightly oblique, angled above and rounded below; peristome slightly thickened, sometimes with internal whitish or pinkish lip, lower and columellar margins of which are reflected, columellar margin twisted, upper and lower vertices joined by parietal callosity.

Body (Figs. 44, 45) yellowish-grey in colour with irregular and pale-yellowish spots; tentacles long and slender with little eyes at base; mantle margin with 7–11 long, tentacle-like appendages on right side and 4–6 similar ones on left side, folded on the shell; foot long, rounded anteriorly and pointed posteriorly.

Genitalia: general scheme of diaulic ditrematic type (see Giusti et al., 1995 and cited references); distal male genitalia (Figs. 31, 32) with two retractor muscles, one at base of penial sheath and one at base of preputium; penial sheath slender and long, containing penis and long and wide preputium, inside preputium is located a large sucker-like structure; the penial sheath is about half the preputium long.

DISTRIBUTION AND BIOLOGY. Allochthonous species, it was introduced into Europe from North America (Taylor, 2003) and it is diffused throughout Italy (Girod et al., 1980; Manganelli et al., 1995; Cianfanelli et al., 2007). Its first report in Italy dates back to Issel (1866, sub *Physa pisana*); the spread of *P. acuta* was one of the causes of the gradual rarefaction of the indigenous *P. fontinalis* (Linnaeus, 1758) (Manganelli et al., 2000).

Physella acuta lives in all freshwater systems, lotic and lentic, on rocks, water weeds and other vegetation in rivers, streams, ponds, swamps, drains, water tanks, fountains and similar habitats. Species of great ecological value, it also resists in urbanized and polluted environments and at short periods of drying.

STATUS AND CONSERVATION. This species is classified as “Least Concern” by Cuttelod et al. (2011) and in IUCN Red List (Van Damme et al., 2012).

REMARKS. *Physella acuta* is common in the study area (Table 1), living with stable and numerous populations in natural and artificial waters of the Palermo surroundings, where it is found mainly in the gardens water tanks of the city center and in the “gebbie”, still remaining, in the citrus groves of the plain of Palermo and the valley of the Oreto River.

Familia PLANORBIDAE Rafinesque, 1815
Subfamilia PLANORBINAE Rafinesque, 1815
Genus *Ancylus* O.F. Müller, 1773

Ancylus propе ***fluviatilis*** O.F. Müller, 1774

DESCRIPTION. Shell conical (aperture oval) (Figs. 46, 47), convex anteriorly and concave posteriorly in section, slight blackish in colour when fresh because it is almost always incrusted, really it is yellow-whitish, sub-transparent; height 4–5.1 mm, maximum diameter 6.6–7.8 mm, some specimens are encrusted; external surface with distinct longitudinal ridges starting from apex and crossed by thin concentric growth lines; apex subobtuse curving backwards; aperture oval.

Body: mantle, head and foot blackish irregularly pigmented; tentacles short and triangular with obtuse apex and little eyes at base; foot smaller than shell opening.

Genitalia not examined in this population; for general features see Girod et al. (1980) and Giusti et al. (1995).

DISTRIBUTION AND BIOLOGY. Pfenninger et al. (2003) and Albrecht et al. (2006, 2007), with molecular genetic studies, subdivide the populations of *Ancylus fluviatilis*, which were attributed to almost all the Euro-Mediterranean populations including Italy and Sicily, in four clades (Albrecht et al., 2007): *A. fluviatilis* mainly in Northern Europe, but reaching southern limits in Spain, France, Northern Italy and Slovenia, *Ancylus* sp. A from S-Portugal, *Ancylus* sp. B mainly found in the Mediterranean region, from the Canary Islands, Morocco, Italy, through to Greece and Turkey, *Ancylus* sp. C mainly found in the western Mediterranean region, from Portugal and Spain to Italy. *Ancylus* sp. B and *Ancylus* sp. C are also known from Sicily.

The *Ancylus* live in well oxygenated and running freshwater, natural and artificial as springs, lake margins, river, fountains, and irrigation canals, crawling on rocks, stones, and plants; they feed on vegetal debris, algae and periphyton.

STATUS AND CONSERVATION. *Ancylus fluviatilis* sensu lato is classified Least Concern (LC) by Cuttelod et al. (2011). In IUCN Red List the four species referable to *A. fluviatilis* have been assessed as Least Concern (LC) except *Ancylus* sp. A wich is considerable as Data Deficient (DD) (Seddon et al., 2012).

The sicilian populations of *Ancylus*, widespread throughout the region, have been steadily declining in the last few years.

REMARKS. The specific attribution of the different populations of *Ancylus* is currently problematic, considering the many taxa described in the past years in almost all distribution areas. In particular, Benoit (1875) cites for Sicily ten different species, including *A. tinei* Bivona, 1839 described for Palermo surrondings (Bivona, 1839: "*… Le strie longitudinali, di cui è munita, sono più o meno notevoli… maggiore spessezza … maggiore incavamento della conchiglia medesima*"). This description refers to the samples from Micciulla, where few live specimens were found in the Source of Fontane, in the Micciulla irrigation canals and other shells were found in almost all the sampled sites (Table 1). For areas very close to our study area are reported populations of *Ancylus* by Bivona (1839 sub *A. tinei*: "*Trovasi comunissimo nel beveratojo sopra il convento di Baida*"), Calcara (1845 sub *A. fluviatilis*: "*beveratojo sopra il convento di Baida*"), and by Benoit (1875, sub *A. tinei*: "*nelle sorgive delle montagne di Boida* [Baida]").

Genus *Planorbis* O.F. Müller, 1774

Planorbis planorbis (Linnaeus, 1758)

Description. Shell sinistral, planispiral, discoidal (Figs. 48–50), with upper border flattened and lower border slightly concave; brown or reddish-brown, often encrusted, height 1.6–2.8 mm, maximum diameter 5.5–9 mm; external surface with thin growth lines; spire 5–6, last whorl slightly dilatated toward the end with rounded upper keel; sutures deep; aperture oval, transverse, angled in corrispondence with upper keel, peristome simple.

Body is black in colour; foot elongated posteriorly; tentacles long and slender with small eyes at base; the mantle pigmentation and foot are dark-grey.

Genitalia characterized by the prostate whit 35–57 digit-like diverticula; preputium moderatly elongate (1.6 to 2.2 mm).

DISTRIBUTION AND BIOLOGY. Holopalaearctic. It is present and diffused throughout Italy (Girod et al., 1980; Manganelli et al., 1995).

Planorbis planorbis lives between the aquatic vegetation of natural or artificial freshwaters, stagnant or slow-moving.

STATUS AND CONSERVATION. This species is classified as "Least Concern" by Cuttelod et al. (2011) and in I.U.C.N. Red List (Seddon & Van Damme, 2014).

REMARKS. In the Micciulla territory there are some small living populations of *P. planorbis*: in the spring of the Scirocco House, in the Source of Fontane, in the irrigation canals and "gebbie" of the citrus grove (Table 1).

It is diffused but localized in Sicily. This species was common in the artificial water system of Palermo surrondings (Lo Brano & Sparacio, 2006) but now is in decline.

Planorbis moquini Requien, 1848

Description. Shell sinistral, planispiral, concave on both sides (with upper side more concave than lower) (Figs. 51–53), subtransparent, finely striated, widely umbilicated; height 1.2–1.6 mm; maximum diameter 2.8–3.4 mm; reddish-brown in colour, with some specimens encrusted and corroded; spire with 3–4 regularly growing whorls, which are convex above and below; last whorl dilatated; sutures deep; aperture oval and transverse; peristome simple, interrupted.

Body is black in colour; foot elongated, anteriorly rounded, posteriorly pointed; tentacles very long and slender with small eyes at base; the mantle pigmentation is dark-grey.

Genitalia (Fig. 33). The preputium is on the dorsal side darkly pigmentated, 3 times penial sheath lenght, from the penis sheath starts a longer and slender vas deferens The prostate gland bears 10–12 diverticules. The bursa is oval with a short and thin bursa duct.

STATUS AND CONSERVATION. This species is classified as "Least Concern" by Cuttelod et al. (2011) and in I.U.C.N. Red List (Prié, 2010).

Distribution and Biology. *Planorbis moquini* is reported in various regions of central-southern Italy, Sicily, Sardinia (Girod et al., 1980; Manganelli et al., 1995) and Maltese Islands (Giusti et al., 1995).

However, *P. moquini* has uncertain distribution because has been confused for a long time with other Planorbid species, requiring new anatomical data for confirmed records.

Particularly, anatomical study of the small planorbids from Tuscan Archipelago, Sardinia, Corsica, Sicily and Maltese Islands showed similar structure of genitalia and was determined as *P. moquini* (Giusti, 1976; Giusti & Castagnolo, 1983; Sparacio, 1992; Giusti et al., 1995).

Glöer & Zettler (2009) redescribe the conchological and anatomical characters of the topotypes of *P. moquini* from Corsica and they confirmed that it is a valid species. Glöer & Zettler (2009) report, also, that *P. moquini* and *P. agraulus* Bourguignat, 1864, redescribed by Glöer & Bouzid (2008) locus typicus: Algeria, are two distinct species and they are distinct from *Planorbis* sp. of Sardinia and from *P.* cf. *atticus* Bourguignat, 1852 of Crete. They conclude that "*... the Planorbidae of the Mediterranean are poorly known and more diverse than is currently understood and their remains a number of taxonomic problems to be resolved*".

Planorbis moquini is found in stagnant or slow-moving freshwaters, natural and artificial, usually oxygenated and with rich vegetation.

Remarks. *Planorbis moquini* is a rare species in the study area; it found only in a few living samples at Qanat Savagnone (Table 1).

They showed similar structure of genitalia of *P. moquini* (Giusti, 1976; Giusti et al., 1995; Glöer & Zettler, 2009) but this samples have the conchological difference from other populations, well described, of Corsica (see Glöer & Zettler, 2009) and of Maltese Islands (see Giusti et al., 1995).

Particularly, *P. moquini* from Micciulla shows more robust shell, the most oval aperture and the last whorl higher than in *P. moquini* from Corsica; from the specimens of Malta they differ for smaller size and higher and convex whorls.

Also from these short observations, and from what Glöer & Zettler (2009) reported above, it appears clear that the true identity of the different populations currently attributed to *P. moquini* has not yet been clarified.

Genus *Planorbella* Haldeman, 1843

Planorbella duryi (Wetherby, 1879)

Description. Shell sinistral, planispiral, robust, concave on both side (lower side more concave than upper) (Figs. 54–57), reddish or yellowish-brown in colour; height 7.2–11.8 mm; maximum diameter 15.1–2.1 mm; external surface with thin and irregular striae; spire with 4–5 regularly and rapidly growing convex whorls; last whorl dilated slightly angled above; sutures deep; aperture oval, peristome simple.

Body reddish-brown in colour with multiple and very small white-yellowish spots; tentacles moderately elongated, robust, with eyes at base; foot wide anteriorly and pointed posteriorly.

Male genitalia consisting of penial sheath, preputium, lateral accessory duct and vas deferent (Fig. 34). Penial sheath, inserted laterally and inferiorly of preputium, is narrower to the base and larger and rounded to apex where an elongated vas deferent is inserted; preputium is wide and rounded with a penial accessory duct. Proximal internal cavity of penial sheath with the penis well developed, conical, corrugated; a muscular ring separates this cavity from distal cavity which coincides with the preputium lumen where there is an elongated preputial organ.

Distribution and Biology. Originally from Florida, USA (Wetherby, 1879), *P. duryi* was introduced to different parts of the world, including Europe (see also Welter-Schultes, 2012: range map Europe). In Italy it was reported by Giusti et al. (1995) and Manganelli et al. (1995) from Latium and Sicily, Alexandrowicz (2003) and Mienis (2004) from Albano Lake, Cianfanelli et al. (2007) from Liguria, Tuscany, Puglia and Sicily, Reitano et al. (2007) from Sicily.

Another similar North American planorbid, *P. anceps* (Menke, 1830), has been reported in Italy (Tuscany, River Frigido) by Henrard (1968 sub *Helisoma anceps*). *Planorbella anceps* reported by Zettler & Richard (2003) from Sicily (Siracusa) is actually *P. duryi* (see Cianfanelli et al., 2007).

Planorbella duryi is sold for aquaria in Europe and its presence is caused by the release of aquarium specimens or introduction of fish (see quoted bibliography). It feed on plants, detritus, dead animals, algae and vegetables. Animals can survive short periods of drought staying deeply inside the shell.

STATUS AND CONSERVATION. Classified as “Least Concern” by Cuttelod et al. (2011) and in I.U.C.N. Red List (Seddon & Van Damme, 2014).

REMARKS. Allochthonous species, widespread in Sicily and in the Palermo surroundings (Reitano et al., 2007), where it is now present in water tanks and fountains of the city gardens (Orto Botanico, Parco della Favorita, Villa Tasca, University Polyclinic, Giardino Rosa Balistreri).

In Micciulla, some living specimens were found in a small water tank.

Superordo NERITAEMORPHI Koken, 1896
Ordo NERITOPSINA Cox et Knight, 1960
Superfamilia NERITOIDEA Lamarck, 1809
Familia Neritidae Lamarck, 1809
Subfamilia Neritinae Lamarck, 1809
Genus *Theodoxus* Montfort, 1810

Theodoxus meridionalis (Philippi, 1836)

DESCRIPTION. Shell semi-globose (Figs. 58–60), robust, with 2½–3 spires separated by shallow sutures, often encrusted and corroded specially at apex; height 3–4.2 mm; maximum shell diameter 3.8–5.8 mm; aperture height 2.9–4.0 mm; aperture diameter 3–4.5 mm; it is almost always completely black in colour with irregular lines yellowish-brown almost always broken in small spots; the operculum is yellow-orange on the outside face, whitish inside; the last whorl is very developed and represents almost all the shell; the aperture is large, semi-elliptical, with an extensive, white and shiny columellar callus, obliterating the umbilicus; apex rounded; operculum with a large knob at the base of the opercular ridge, connected to the callosity underlying it, and with the absence of the lamella (Vitturi & Catalano, 1988; Bodon & Giovannelli, 1995; Bandel, 2001).

Body blackish-gray in colour, tentacles short and thin; eyes pedunculated; foot oval, yellowish, with small black spots.

Genitalia with penis located on the right side of the head; females have two genital orifices: an oviduct and a vaginal orifice; the escretor apparatus has only one functional nerve (the left).

DISTRIBUTION AND BIOLOGY. Sicily and Tunisia (Girod et al., 1980; Kristensen, 1986; Bodon et al., 1995; Zettler & Richard, 2003; Bodon et al., 2005). *Theodoxus meridionalis* in Sicily is found in cold and oxygenated waters of rivers, streams and springs and close canals and water tanks.

STATUS AND CONSERVATION. This species is classified as “Least Concern” in IUCN Red List (Zettler & Van Damme, 2010) and by Cuttelod et al. (2011). In Tunisia it was considered “Not Evaluated” (Van Damme et al., 2010).

Theodoxus species are in decline due to human alteration of natural habitat.

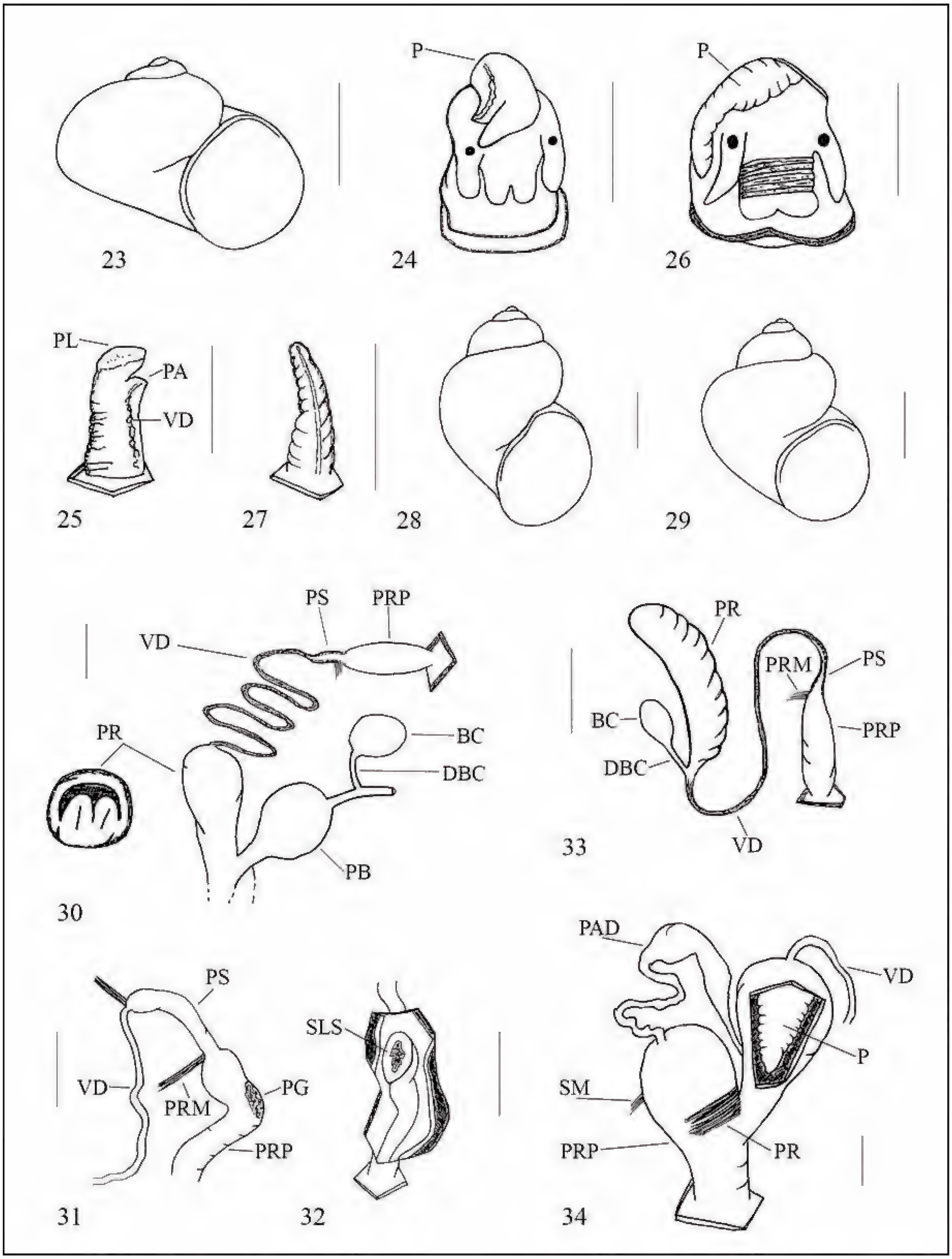
REMARKS. In the study area there are two populations: one, small, living in the spring of the Room of Sirocco and another, more numerous, living in the Source of Fontana. Also reported by Pirajno (1840 sub *Nerita fluviatilis* var. *nigra*) from “*Boccadifalco*” very close to Micciulla and by Calcara (1845: sub *Nerita baetica*) from the “*sorgive del Gabriele*”.

It is uncommon throughout the Sicilian territory, disappeared from many localities also in the surroundings of Palermo (Pirajno, 1840; Benoit, 1875, 1882; De Gregorio, 1895; Cassarà, 1951; Bodon et al., 2005).

Populations of this species from Siracusa province (Anapo, Asinaro and Lato rivers) were examined with a cariological study by Vitturi & Catalano (1988) who demonstrated the haploid number of chromosomes n=12+h and the diploid values 2n=25 in males (X0) and 2n=26 (XX) in females.

Bunje & Lindenberg (2007) studied by molecular genetics numerous *Theodoxus* populations identifying six major clades. The clade D, where *T. meridionalis* falls, is distributed throughout the Mediterranean area. According to these authors, the current specific differentiation seems to be related to the Pliocene’s geo-climatic events.

Classis BIVALVIA Linnaeus, 1758
Subclassis Eulamellibranchia Blainville, 1824
Superordo Heterodonta Neumayr, 1884
Ordo Veneroidea Rafinesque, 1815
Superfamilia Sphaerioidea Deshayes, 1855 (1820)
Familia Sphaeriidae
Genus *Pisidium* Pfeiffer, 1821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Figures 23–25. *Islamia pusilla*. Fig. 23: shell. Fig. 24: body. Fig. 25: dorsal surface of penis. Figures 26–29. *Pseudamnicola moussonii*. Fig. 26: body; Fig. 27: penis; Figs. 28, 29: shells. Figure 30. *Stagnicola fuscus*, penial complex. Figures 31, 32. *Physella acuta*: penis with open preputium. Figure 33. *Planorbis moquini*, penial complex. Figure 34. *Planorbella duryi*, penial complex. All scale bars equal 1 mm except for the bars in figures 23–25 which equals 0.5 mm.

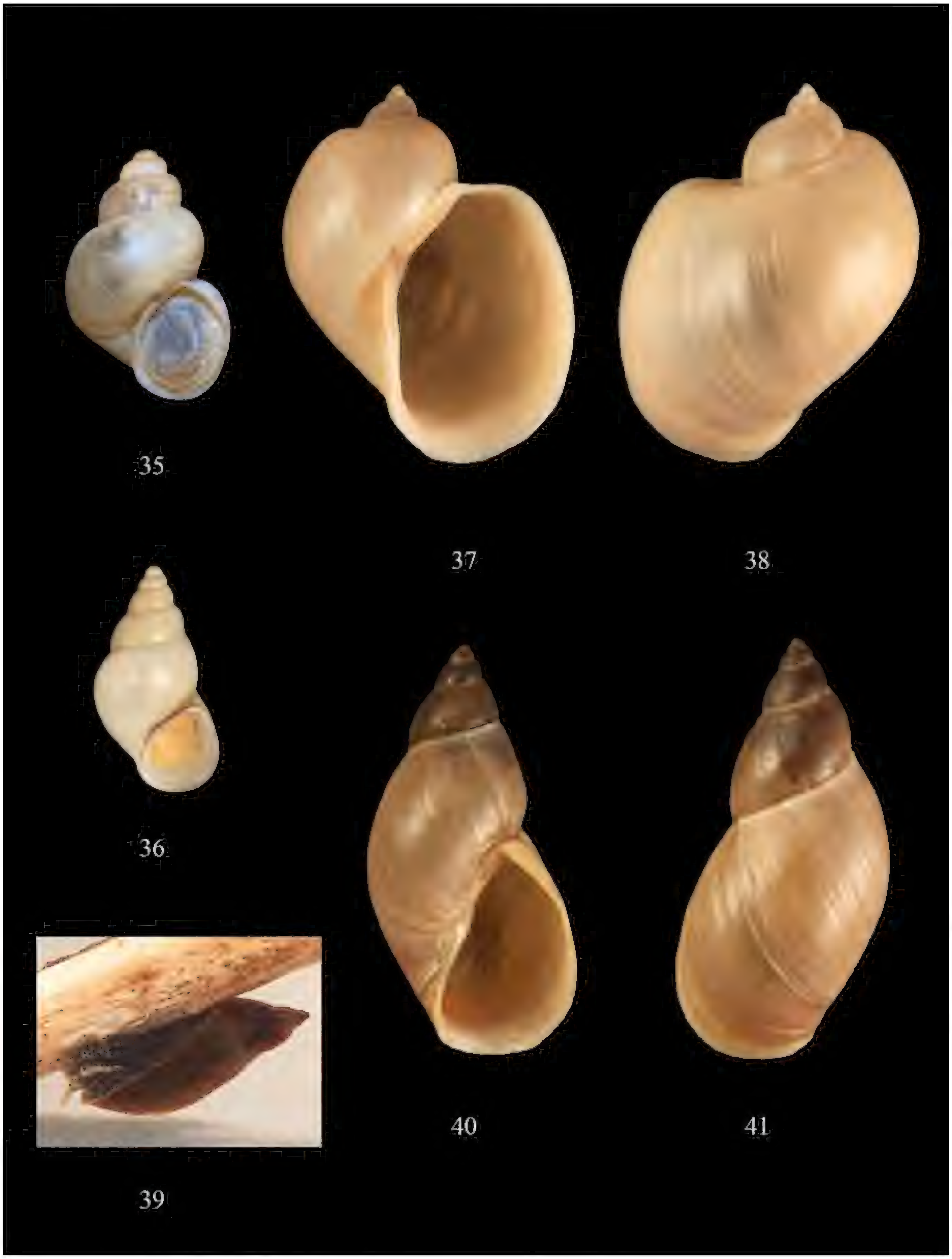
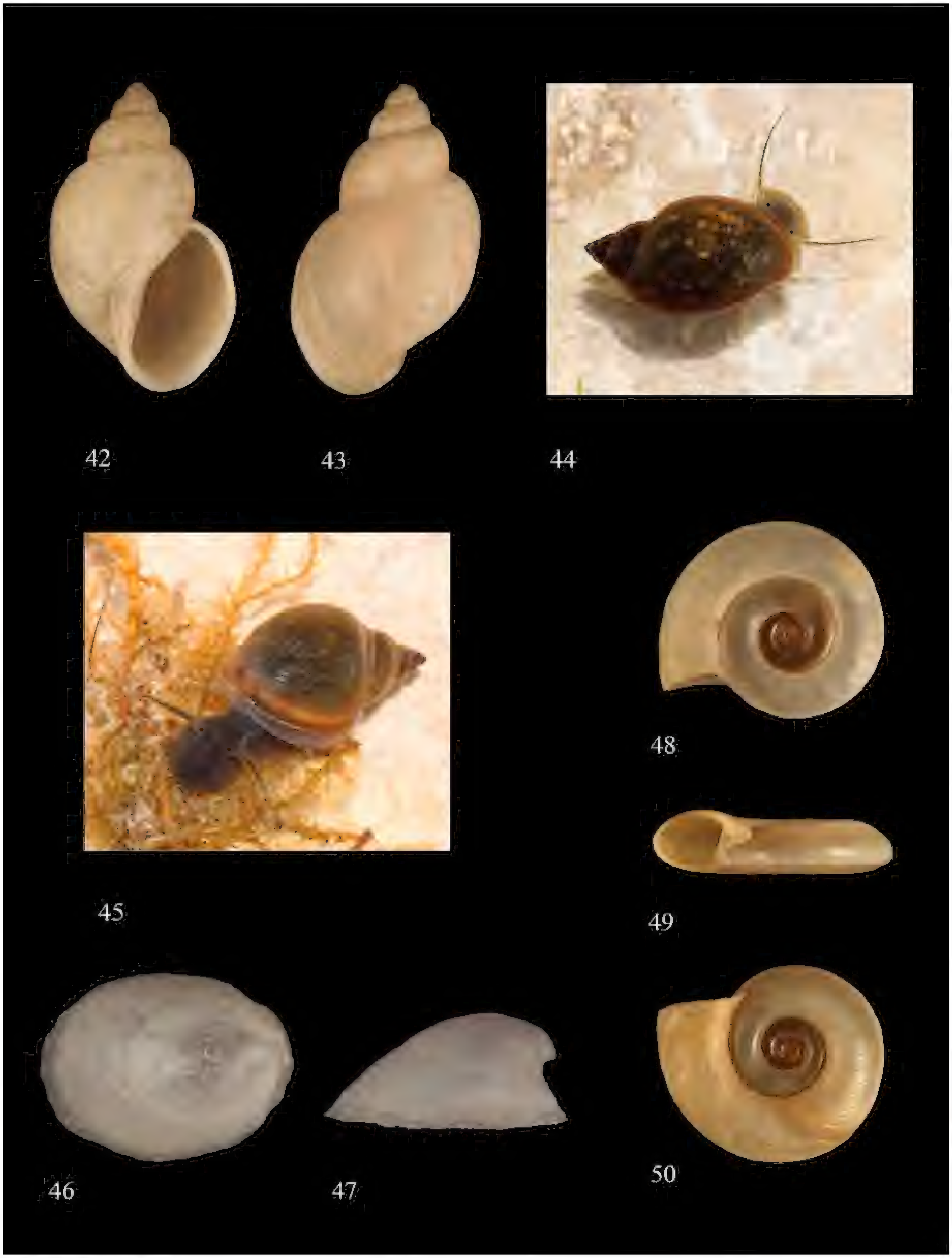
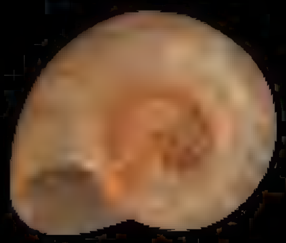


Figure 35. *Bythinia leachii*, Qanat Scibene, shell, height 5.4 mm. Figure 36. *Potamopyrgus antipodarum*, Qanat Gesuitico Alto, shell, height 5 mm. Figures 37, 38. *Radix auricularia*, Ru Gebbi, shells, height 20.1 mm. Figures 39–41. *Stagnicola fuscus*, Gebbia Villa Belvedere, live specimen and shells, height 16.3 mm.



Figures 42, 43. *Galba truncatula*, Gebbia Santacolomba, shells, height 8 mm. Figures 44, 45. *Physella acuta*, Micciulla, live specimens, shells, height 10 mm. Figures 46, 47. *Ancylus* prope *fluviatilis*, Source of Fontane, shells, height 5 mm. Figures 48–50. *Planorbis planorbis*, Gebbia La Mantia, shells, maximum diameter 8.4 mm.



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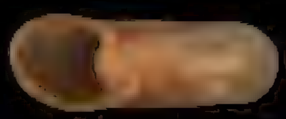

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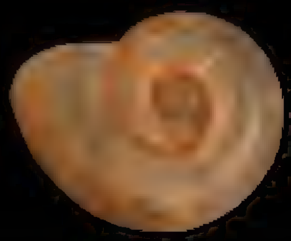

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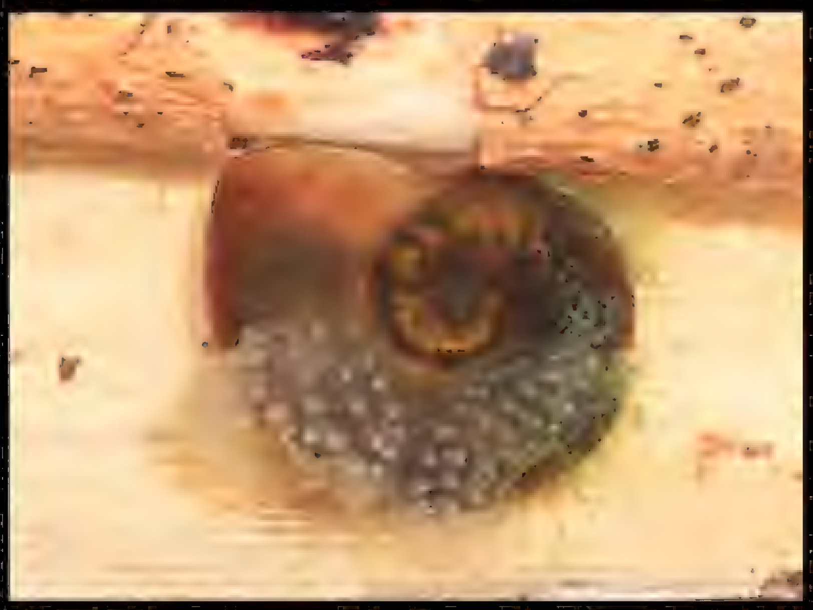

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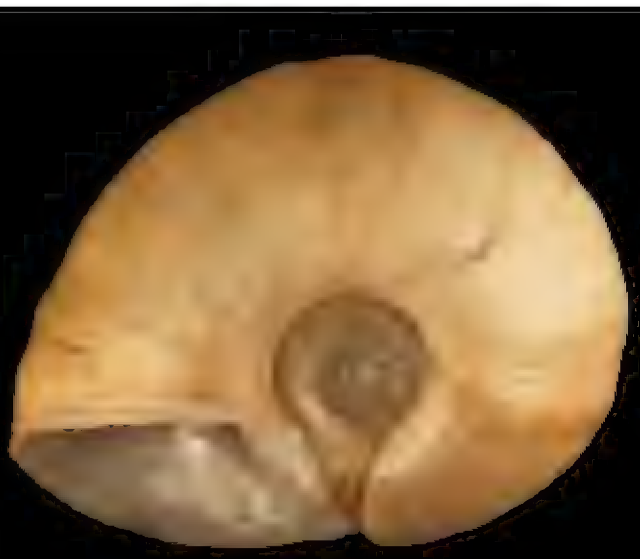

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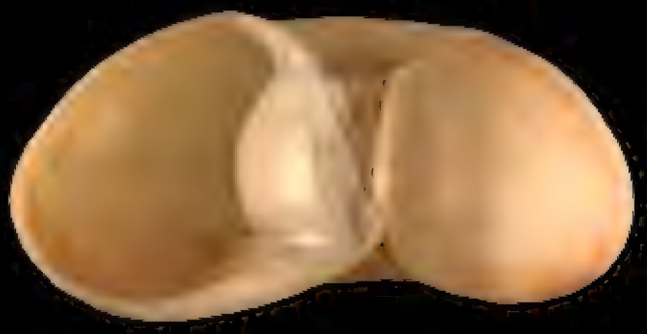

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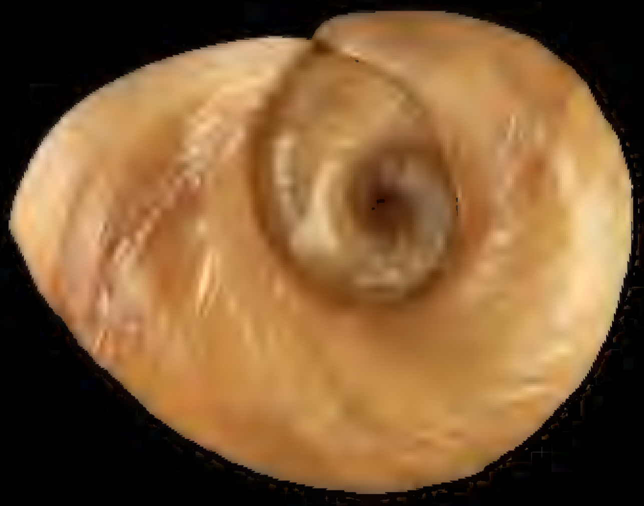

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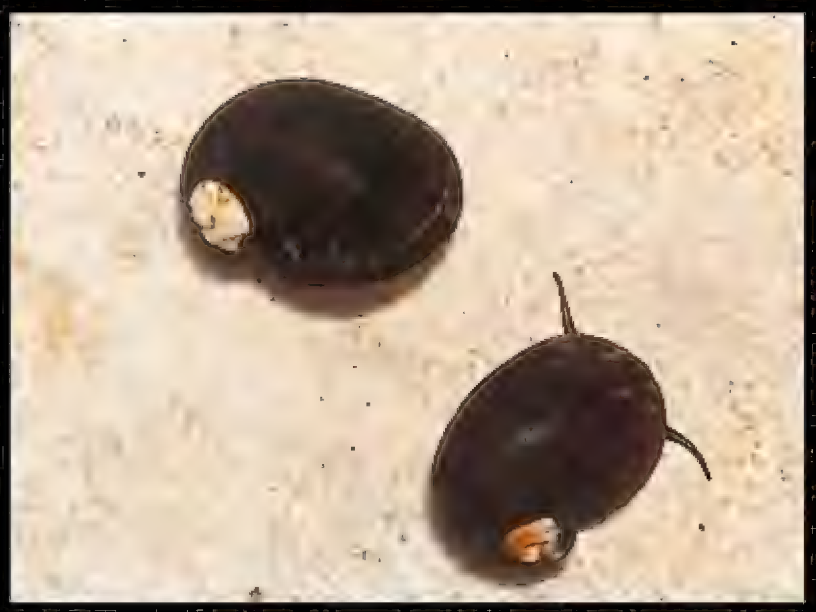

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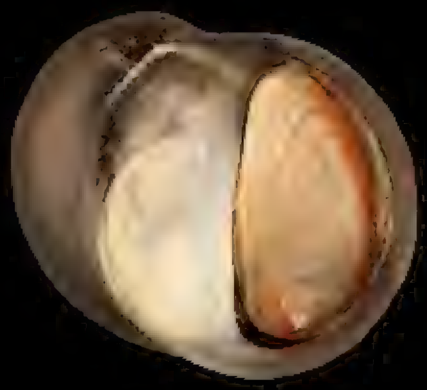

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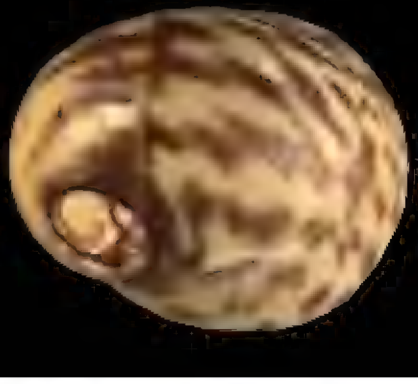

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Figures 51–53. *Planorbis moquini*, Qanat Savagnone, shells, maximum diameter 3 mm. Figures 54–57. *Planorbella duryi*, Micciulla, shells and live specimen, height 10.2 mm. Figures 58–60. *Theodoxus meridionalis*, Source of Fontane, live specimens (Fig. 58), shell with operculum, height 3.8 mm (Fig. 59) and honed shell, height 3.5 mm (Fig. 60).

Pisidium personatum Malm, 1855

DESCRIPTION. Shell bivalve, oval in outline, little convex, lower edge well arched, pale yellow in colour, white or grayish post mortem, subtransparent; length 2.2–4.4 mm, height 1.9–3.3 mm, width 1.7–3.2 mm; external surface with thin and irregular striae, anterior half slightly longer than posterior, umbones only just posterior, broad, but not prominent; hinge plate of both valves robust characterized by the presence of a "callus" between the ligament pit and the base of 1 and 3 posterior lateral teeth (P1 and P3), more evident on the right valve close to or fused to the base of P3. Three anterior lateral teeth (A3) and P3 moved at the margin of the shell.

Animal with small and pointed foot, yellowish in colour.

DISTRIBUTION AND BIOLOGY. Holopalaearctic-Ethiopian, including all Italy (Kuiper, 1964; Castagnolo et al., 1980; Castagnolo, 1995; Bodon et al., 2005; Pezzoli & Giusti, 2006).

Pisidium personatum lives in all stagnant and slow moving waters, also in subterranean waters. It is frequent in low and medium altitudes but it occurs at higher altitudes in the Alps (Nardi & Castagnolo, 2009).

STATUS AND CONSERVATION. Classified as "Least Concern" by Cuttelod et al. (2011).

REMARKS. *Pisidium personatum* is present in this study area with several small but stable populations (Table 1). It is a common species in Sicily, where it is found in different environments, including canals, drinking water, wells or small cavities even with little light or almost darkness.

CONCLUSIONS

The Palermo Plain is now almost completely urbanized as includes, in addition to the city of Palermo, many other neighboring towns with a total of about 1,000,000 people. Particularly in the second half of 1900, there was an uncontrolled development of buildings, without the construction of adequate networks and aqueducts, causing the spread of cesspools and the transformation into sewers of many streams and artificial canals, including the Oreto River.

All these waterways are in communication with the underground aquifers of the Plain and even the old sewerage system of Palermo's urban center is subject to frequent sewers breakage and discharge of slurry. In addition, numerous wells for drawing water from the aquifer were made without proper controls. All this resulted in over-exploitation of the underground water with consequent drainage of some springs and increased intrusion of sea water into the aquifer itself.

At the same time, occurred the disappearance of almost all the natural freshwater environments of the Palermo Plain and the strong reduction of agricultural land including its complex water-catching and distribution systems (gebbie, saje, etc.) which contributed to the creation of a complex ecosystem with articulated trophic networks (Riggio, 1976; La Mantia, 2004).

In this environmental degradation the territory of Micciulla, now completely inside the city of Palermo, witnesses a perfect integration of natural environments and agro-systems of the Palermo Plain, representing the perfect metaphor for sustainable development.

In the Palermo Plain, it is already documented for various other groups of animals a passage from the original natural habitats to the agrarian ones with biodiversity conservation.

This is the case of the loquat, *Eryobothria japonica* (Thumb.), an allochthonous species long cultivated in Sicily and, in particular, in the Conca d'Oro. Many loquat orchards contribute to creating new ecological niches for different bird species (see La Mantia, 2016) and insects xylophages, in particular Coleoptera Cerambycidae (Bellavista et al., 2015).

Fourteen (14) species of freshwater molluscs have been surveyed (Table 1). Of particular importance are the populations of *Islamia pusilla*, species bound to water springs and *Theodoxus meridionalis*, Sicilian endemism restricted to well-oxygenated waters, which has disappeared from numerous places in the Palermo area. The consistency of the *Pseudamnicola moussoni* and *Pisidium personatum* populations is good, both species linked to clean and oxygenated waters, with wide diffusion and great ecological value. *Stagnicola fuscus*, *Radix auricularia*, *Galba truncatula*, and *Planorbis planorbis* are present with small populations but still found in Palermo area, while no data is available on the consistency of the populations of *Bythinia leachii*, *Planorbis moquini* and *Ancylus* prope *fluviatilis*.

It is worth noting the presence of three allochthonous species: *Physella acuta*, widespread and common since 1900 throughout Sicily, *Potamopyrgus antipodarum* and *Planorbella duryi*, species introduced recently but continually expanding.

The largest number of living populations are found in the Fontane Spring (6) thanks also to the good natural conditions of these environments. This is also the case of the Qanat Scibene (5) and Qanat Savagnone (4), which receives clean and oxygenated waters from the Scibene Spring, despite the small area useful for malacological researchs, restricted to the qanat entrance from the "Camera dello Scirocco" (scirocco room) (see Fig 15).

The Qanat "Gesuitico Alto", however, flows completely underground and is aphotic (i.e. having no sunlight): we found empty shells and some living specimens of *Potamopyrgus antipodarum*, an allochthonous species which, throughout the entire territory studied, at the moment, was found only in this particular environment.

Within the gebbie examined we found, in the whole, a few living species, probably due to either the fast water supply they are characterized by, as being used for irrigation, and the homogeneous eco-

Species	**Source of Fontane**	**Qanat Scibene**	**Qanat Savagnone**	**Qanat Gesuitico Alto**	**Gebbia La Mantia**	**Gebbia Villa Belvedere**	**Gebbia Santacolomba**	**Ru Gebbi**	**Saje Fondo Micciulla**	**Water tank Micciulla**
Bithynia leachii		S							S	
Islamia pusilla	L	L	L							
Pseudamnicola m. moussonii	L	L	L	S				S		
Potamopyrgus antipodarum				L						
Physella acuta	L	L		S	L	L	L		S	L
Galba truncatula					S	S	L		L	
Radix auricularia						S		S		
Stagnicola fuscus	S	S			S	S	S		L	
Ancylus prope *fluviatilis*	L	S	S	S					L	
Planorbis moquini	S	S	L	S						
Planorbis planorbis	L	S			S	L	S		L	
Planorbella duryi										L
Theodoxus meridionalis	L	L	S	S					S	
Pisidium personatum	L	L	L	S	S				L	

Table 1. Freshwater snails found in Micciulla territory (2009–2016). L: live specimens, S: shell/s.

logical conditions typical of this environment; in addition, periodically, gebbies are emptied and cleaned.

Many more species can be found, on the other hand, in the saje of Fondo Micciulla, which have a considerable territorial extension, a good diversification of ecological niches and are nearly always fed by running waters.

Quite predictable was the presence of *Planorbella duryi* within an ornamental tank.

The multiple connections between all these natural and artificial systems allow to find, almost everywhere, empty shells transported remotely from the original places.

Some species have high colonization capacity and ecological adaptability to moving easily within the study area as *Stagnicola fuscus*, *Galba truncatula*, *Radix auricularia*, *Physella acuta*.

It is essential to plan conservation, recovery and enhancement programs for both natural environments and farmlands occurring within the Palermo Plain (see La Mantia, 2006, 2007). It would be necessary, therefore, to re-evaluate the role played by water throughout this entire system and to ensure its constant availability to farmers in order to slow down the processes of land abandonment (La Mantia & Rotondo, 2014).

The ecological value of these agro-ecosystems is mostly linked to the permanence of water in the irrigation system and soil and its absence for many months in the distribution channels results in disappearance of entire communities of plants and animals, not least that of freshwater molluscs object of this work.

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